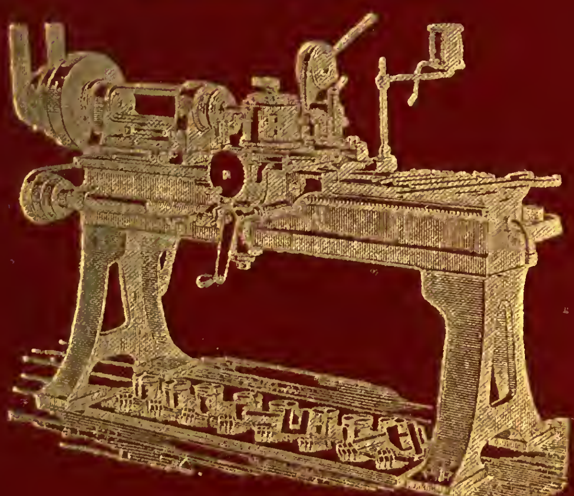
SCREWS AND CREW-MAKING, THE MILLING MACHINE &c. &c.



BRITANNIA COMPANY,
COLCHESTER.

Screws & Screw-Making.

SCREWS

AND

SCREW-MAKING,

WITH A CHAPTER ON

THE MILLING MACHINE.

A COMPLETE TREATISE ON SCREW-MAKING IN ALL ITS BRANCHES, EMBRACING MOST RECENT METHODS, AND CONTAINING THE REPORTS WHICH ORIGINATED MODERN STANDARD SCREW-THREADS.

WITH 95 ILLUSTRATIONS.

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PREFACE.

IN a few words we will endeavour to foreshadow the contents of this treatise, the largest volume devoted entirely to screws and screw-making. We are familiar with all the smaller books on this subject, and it is in consequence of failing to find in either of them information frequently asked of us by clients, that we have been impelled to issue the present volume.

Much of the information contained in this book has hitherto been inaccessible owing to its being scattered through the costly and little read "Transactions," &c., of several learned societies. For the first time we have gathered together and placed within the reach of any mechanic all the authentic papers on the subject.

The whole system of screws, their thread-forms, pitches, and diameters, have been dealt with in the most thorough manner at different times by the several committees appointed for the purpose by powerful organisations. We therefore give the reports of these committees, unabridged and without comment, commencing with the classic paper by Whitworth, in which the principles that govern the dimensions of the now universally recognised Whitworth Screws are set forth. This paper was communicated to the Institution of Civil Engineers in 1841, and was the first attempt at systematising screws which at that time were made hap-hazard.

About a quarter of a century later the Americans took steps to systematise their screws, which then differed in form from Whitworth's standard. The considerations which led to the adoption of Sellers' system are given in the body of this book.

The Continent of Europe now finds itself constrained to adopt some system so as to obtain uniformity in the screws used there. Considerations are now pending, but we doubt not that the Whitworth system will be adopted.

Small screws — by which we mean those under $\frac{1}{4}$in. diameter—are not comprehended by the Whitworth nor the Sellers systems. These small screws, which are chiefly employed in horological mechanism, were taken in hand by the Geneva Society of Arts, and a remarkably thorough system was tabulated by Professor Thury, which is now adopted in the horological trades on the Continent. On the recommendation of a committee of the British Association for the Advancement of Science, Professor Thury's system has been adopted in the United Kingdom.

We have printed all these reports unabridged, and their perusal will explain all that has been done in the way of theorising on screws.

The table of wheel trains to cut various thread-rates by the aid of guide-screws, extends further than any one we have met with. It includes nearly 1,000 thread-rates, ranging from the coarseness of one turn in sixteen inches to the fineness of one hundred turns per inch.

In the practical part we have endeavoured to give a clear and concise explanation of the methods and processes of screw-making. Many illustrations are shown of the most important machinery used for the purpose, which we are continually making.

With every confidence that this treatise supplies a want hitherto not fully met, we offer it to all who are interested in mechanism of which screws form an integral part.

We shall be at all times willing to correspond with any reader who may require information not given, and shall be glad to hear of any error in figures that, even with the greatest care, may have remained undetected in the tables, so that correction can be made in a future edition.

BRITANNIA CO.

ENGINEERS' TOOL FACTORY,
COLCHESTER, 1891.

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SCREWS

AND

SCREW-MAKING.

CHAPTER I.

ON SCREWS AND SCREW-MAKING.

SCREWS, at least in one if not more of their various forms, are familiar to all mechanics; they have been aptly termed the cement by which parts of machinery are fastened together. The utility of screws and bolts—which unite distinct parts easily, hold them in position firmly, and allow them to be separated readily—is so generally evident that comment is needless. The essential qualities in a screw are: Power to draw together the parts which it is intended to unite; strength to resist the strains to which it may be liable; and durability to stand the wear and tear of fixing and unfixing. These three qualities are the essentials of all screws, and though power, strength, and durability, may at first glance appear to be somewhat similar terms yet each is quite distinct as above defined.

Screws allow of great diversity. They may be of any diameter. The thread may be of any degree of coarseness or fineness. It may be wound either to the right or to the left, and so produce either right- or left-handed screws. Double,

triple, and quadruple threads may be made by multiplying the grooves. The section of the thread may be of any arbitrary form. These diverse elements may each be changed and combined differently so that practically endless variations are obtainable.

The diameter of a screw is the measurement over the thread. Ordinary callipers, when applied to a screw, enter the groove more or less, and do not, as shown at A (Fig. 1), indicate the true diameter. Callipers with specially-made wide jaws, as shown at B, give the correct measure. When cutting a thread the diameter is usually determined by turning the blank material to correct size, so that, to gauge the depth of the groove being cut, callipers having rounded jaws like C

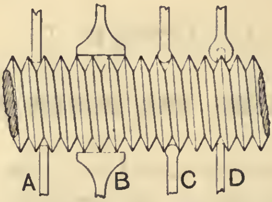

FIG. 1. CALLIPERING A SCREW-THREAD.

are used. A better form for the purpose is shown at D; the male jaw exactly fits the female jaw, and former enters the screw groove just as far as the latter extends over the ridge, and so the points always gauge the screw at half the depth of the thread.

The thread of a screw is a cylindrical spiral ridge, each turn of which is separated from the next by a groove. The form of the ridge gives a distinctive name to a thread, as square, V-shaped, &c. If a right-angled triangle were coiled round a cylinder, the hypotenuse would trace the spiral screw-thread; the base of the triangle equalling the diameter of the cylinder, the height would show the pitch or rise of the thread. When the spiral inclines so that on turning the screw to the right it advances, the screw is said to be right

handed; and when the reverse, left handed. The amount that the ridge projects beyond the groove determines the depth of the thread. The pitch or rise is the amount of

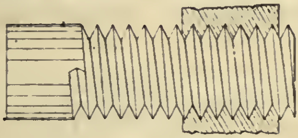

FIG. 2. SINGLE THREAD.

longitudinal motion during one complete rotation of the screw.

When the thread is single, the pitch is the distance between two adjacent turns; but double, triple, quadruple, &c., threads,

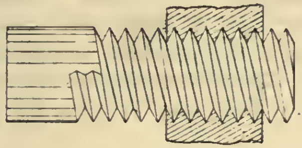

FIG. 3. DOUBLE THREAD.

have respectively two, three, four, &c., ridges between each turn of the thread as shown by Figs. 2, 3, 4, and 5. In each of these illustrations the nut is shown the distance of one turn from the end.

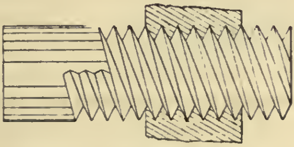

FIG. 4. TRIPLE THREAD.

The pitch of a screw may be described in several ways, and the same thread would be correctly described by either of the following terms: "¼-in. pitch" meaning that the linear

distance between each turn of the thread, measured along the axis of the screw, is a quarter of an inch. Also it may be called "four threads to the inch," meaning that if the screw were rotated in a nut four times, it would travel one inch in the direction of its axis. Again it may be called "·25

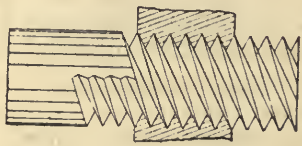

FIG. 5. QUADRUPLE THREAD.

pitch," which is simply the decimal equivalent of the first named vulgar fraction. The term "pitch" may be replaced by the term "rise" in either case. The rake of a thread is the amount that it inclines from a right angle to the axis of the screw: *rake* differs according to diameter, but *pitch* is the same always. This may be seen by an inspection of

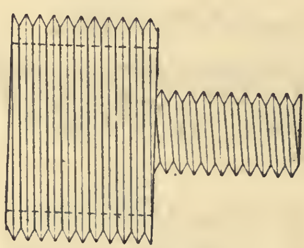

FIG. 6. DIFFERENCE OF RAKE IN SAME PITCH ON DIFFERENT DIAMETERS.

Fig. 6, which shows, on a somewhat reduced scale, a thread of 11 turns per inch, cut on a bolt $\frac{5}{8}$in. diameter, and on a tube $1\frac{3}{4}$in. diameter, as occurs in practice.

The shape and pitch of a thread determine the qualities named first; the diameter being important though it may

be disregarded in this connection, as it affects only the strength of the stem apart from the thread itself. The power of a screw is dependent entirely on its pitch, and, disregarding friction, the power is in inverse ratio to the pitch; that is, the less the pitch the greater the power. The strength and the durability depend on the depth and shape of the thread. If strength only had to be considered in a screw a triangular form of thread would be the best, but the exigency of manufacture demands that the keen angles both of the ridge and of the space be blunted to ensure uniformity; as tools necessary for cutting the triangular threads would soon lose their points, if made acute, and thus cause the threads they cut to be somewhat blunted in the apex of the groove. To meet this practical objection, the tops of the threads and the bottoms of the spaces in angular threads are either rounded, as in Whitworth's standard screws, or truncated, as in the American standard screws.

The proportions given to screws used simply for binding purposes, that is for attaching together the different parts of structures, are empiric, that is to say they are founded upon experiment and the result of practice. The pitch, diameter, and depth of thread do not afford bases from which to determine a formula. And given either two of the above, the third cannot be got by calculation from them. The proportions found suited for a screw of 1in. diameter cannot be adapted to one larger or smaller by simply increasing or decreasing them in like proportion.

Formulæ cannot be given for determining either pitch, depth, or shape of a thread to suit a particular purpose, but subsequent chapters fully discuss the theoretical principles involved in considering the relative merits of different proportions in screw threads. The numerous tables given on subsequent pages show the results of careful and laborious analysis by various authorities, and one of the most essential requisites in screws is uniformity. It is for the purpose of maintaining a workable uniformity amongst the screws produced, according to the measurements given in any one of the tables, that the ridges and the grooves are rounded or truncated, and this becomes

the more necessary as the screws become smaller, when the irregularities in their manufacture become relatively greater.

In selecting a thread for any particular purpose it may be obvious that some are too coarse, others too fine, and some unsuitable in shape. Fine and deep threads are evidently not suited for use in cast-iron, which would crumble away, and coarse shallow threads are equally obviously not suited for use in shallow holes, nor for fine adjustments. The selection of the intervening thread, best suited for any particular purpose, must often be left to individual judgment. In practice, a standard thread should always be used, unless absolutely impossible.

The choice of section for screw-threads is governed by several considerations, such as: Facility of construction; resistance to strain; equality of strength in internal and external screw; resistance to accidental violence, both in making and in using, &c. All these points of consideration are mainly determined by the results of practice, and these give respectively a V-thread, upright sides, proportioning the groove and the thread inversely to the strength of materials and rounding the angles of the V for the above-noted requirements.

For V-threads, the angle varies within the limits of 60deg. and 45deg. The depth of a thread may be conveniently expressed as a fraction of its pitch, and in the ordinary screws in general use this varies from about three-tenths to eight-tenths of the pitch; the average depth being about ·56 of the pitch. The difficulty of making screws is, of course, increased by deepening the thread, and therefore the depth should never be needlessly increased, as this would cause extra torsion on the stem in process of cutting, besides the additional labour of cutting away extra material.

The bursting force of a screw depends upon the angle formed by the sides of the thread. A square thread having its sides at right angles to the bolt has practically no bursting force, whilst a very wide-angled V-thread exerts great bursting force.

There are always three qualities in every screw, irrespective of its dimensions or its shape, as already mentioned, viz., power,

strength, and durability. The power of a thread is entirely dependent on its pitch, that is, the greater the number of threads per inch the greater the power, and neglecting friction the power increases in direct proportion to the fineness of pitch. When the pitch is very coarse the screw will not retain its hold, as may be observed in the case of screws used in fly presses which do not wedge fast. A very fine pitch, on the contrary, may give so much surface-friction that the screw and nut cannot be separated after having been screwed tightly together, or if they have become to an extent cemented together. The strength of a screw is proportionate to its sectional area, measured at the bottom of the thread, differing with various materials. The strength of the thread and of the nut being always, in a properly proportioned screw, in excess of that shown by the area of the screw. The durability depends upon the form of the thread and the accuracy of fitting between the male and the female screw. A difference in the pitch of these, even though very small, will greatly interfere with the fitting.

Unmatching pitches can be screwed together only by making the diameters differ, and the amount of this difference will depend upon the amount of difference in the thread-rates and also upon the length of thread that is to be fitted. Difference in the pitch is much more detrimental to the durability of screw-fitting than difference in diameter. It is also obvious that in order to screw a bolt into a nut having a different thread-rate the diameter of the bolt must be less than the diameter of the thread cut in the nut. From this it is also seen that the more shallow a thread is the greater is the need for accuracy in thread-rate. Deepening the thread decreases the strength of a given bolt by decreasing its sectional area. On the other hand, by enlarging the bearing surfaces the durability is increased. A proper consideration of these two effects enables a suitable mean to be determined.

The illustrations (Figs. 7 to 9) show the effects of slight differences in pitch and in diameter. In Fig. 7 it will be noticed that the bearing of the thread is only on the *opposite* sides of the two most distant turns in the nut or bolt, whichever

is the shorter. As the strength of a screw is almost always used only in one direction, it follows that in this case all the pressure comes upon one thread only. In Fig. 8, which shows

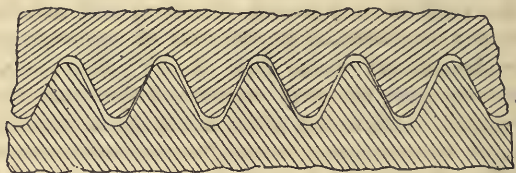

FIG. 7. BAD EFFECT OF SLIGHT DIFFERENCE IN PITCHES OF INTERNAL AND EXTERNAL SCREW.

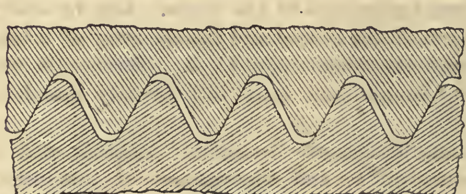

FIG. 8. EFFECT OF LOOSE FIT IN A WHITWORTH SCREW.

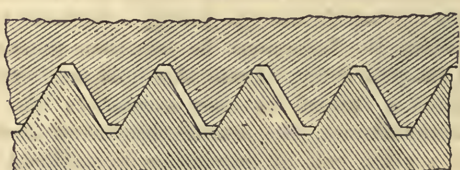

FIG. 9. EFFECT OF LOOSE FIT IN AN AMERICAN SCREW.

the diameter of nut greater than that of the bolt, the surface contact is but very slightly less than when closely fitted. The same is shown in Fig. 9, and in both these it must be remembered that the pressure is in one direction only.

In the early days of screw-cutting, each mechanic who wanted a screw, made it probably without much thought of pitch, or even of exactness in diameter. From this cause screws of most irregular dimensions were commonly found before accurate measurements became general, and before the screw-cutting lathe gave the means of cutting aliquot thread rates.

Doubtless the earliest method of screw-making was to first form a spiral groove in a metal plug and then make teeth upon it to produce a tap. With this an internal screw was produced much more regular in its thread form, and by which numerous copies of the original external screw were easily made. Subsequently the lathe became known in the arts and afforded the means of making greatly improved screws.

The earliest attempt at a system of screw-threads appears to be the table which Messrs. Holtzapffel gave of the screws used in their workshops. This table is given in Chap. XIII. These rates were probably chased by hand with comb-chasers, and the question of any definite number of threads per inch received no consideration, as it would not affect the result, and accurate gauges not being commonly used, aliquot diametrical measurement was likewise neglected. These particular threads having been extensively used, and screwing tackle for their manufacture being sold, the sources of production were distributed amongst various workshops. These threads are cut in with sharp angles, neither the thread nor the groove are either rounded or truncated. Comb-chasers, the correct shape for cutting these threads, may be bought at the tool shops, and ornamental lathes with traversing mandrels have screw-guides of the proper rates. A table given in Chap. XIII. shows the change-wheels that may be used to cut these rates on the ordinary screw-cutting lathe.

A uniform system of screw-threads was first tabulated by the late Sir Joseph Whitworth, and communicated by him in 1841 to the Institution of Civil Engineers (see Chap. II.). To form the basis of his system, he made an extensive collection of screw-bolts from the principal workshops throughout England, and the average thread was carefully measured for different diameters. The dimensions of those $\frac{1}{4}$in., $\frac{1}{2}$in., 1in., and $1\frac{1}{2}$in. diameter

were taken to fix points in a scale by which intermediate sizes were regulated, and the result is a set of screw-threads now known and used universally in fitting up engines and machines of all kinds.

The dimensions of Whitworth's standard threads are tabulated in Chap. XIII. The form of this thread is a triangle, the two sides of the thread enclosing 55deg. The top and bottom of the thread are each rounded off one-sixth of the depth, thus reducing the depth of the thread to two-thirds the height of the full triangle of 55deg.

In America a different form of screw-thread is also in general use. It is known as United States Standard, Sellers' and Master Car Builder's Thread (see Chap. III.). A tabulated

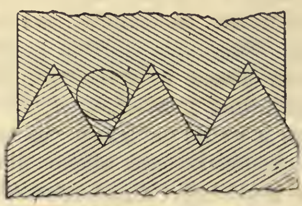

FIG. 10. ADAPTABILITY OF STRAIGHT-SIDED THREAD TO INTERCHANGEABILITY.

statement of all dimensions is given in Chap. XIII. The form of this thread is an isosceles triangle of 60deg., having one-eight removed in a line parallel to the axis of the bolt both at top of thread and bottom of groove, thus reducing the depth of the thread to three-quarters the height of the full triangle of 60deg.

In order to show the adaptation of a thread form having straight sides and flats at the top and bottom to interchangeable work, and also to demonstrate its extreme simplicity as a basis for an interchangeable system of screws, the illustration Fig. 10 is given. An inspection of this will show that, should the tap be larger in diameter, measured over the tops of the threads, but correct in the diameter measured across the sides of the threads, the variation of this outside diameter

from the standard size has no effect upon the fit of the nut. The only noticeable difference would be that the width of the flat top of the thread would be less and the space cut out by the tap would be sharper and deeper. Hence taps for tapping nuts with a thread of this form, if made exactly right in the angle of the thread, that is, having the angle correct, and the diameter measured in this angle of the thread correct as shown by callipering in the way illustrated at C or D, Fig. 1, the outside diameter has no effect, within certain limits, to change the thread size, merely cutting away within the nut more metal outside of the standard diameter. In the case of the bolt which fits this nut, the outside diameter should be made standard, the space between the bottom of the thread of the

FIG. 11. FIG. 12. FIG. 13.

POINT TOOLS FOR CUTTING PLAIN V, TRUNCATED, AND ROUNDING THREADS.

nut and the top of the thread of the bolt allowing particles of dirt to lodge without affecting the fit of the screw. This condition is often applied to the manufacture of taps, and has been found to increase the wearability of the tap in a very marked degree.

Though the shapes of the English and the American standard threads differ greatly in form, still the ratio of pitch to diameter and the depth of thread are practically the same. The method of truncating the American thread, by making the top of the ridge and the bottom of the space flat, is said to be more conducive to accuracy in the production of counterpart screws than the method of rounding them adopted in the Whitworth threads; the exact arc that should be made to each pitch of thread being difficult to

construct practically; but Whitworth's is much more generally in use.

The illustrations (Figs. 11 to 14), which are plan views of tools for cutting various thread grooves, will explain the difficulty more easily. Fig. 11 is a plain V tool, having a sharp point. It only needs to be ground to the required angle on the sides of the V. Fig. 12 is the same tool with its point ground off to make it suit for cutting an American standard thread. Fig. 13 is a similar tool, having its end rounded to suit the bottom of the groove in a Whitworth thread, but such a tool would not round the top of the ridge, hence a comb (Fig. 14), shaped to correspond with top, bottom, and sides of the thread, is necessary to cut the Whitworth screw.

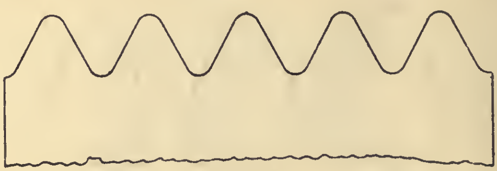

FIG. 14. COMB SCREW-TOOL REQUIRED FOR CUTTING THE WHITWORTH THREAD.

It may be thought that accuracy and interchangeability of the Sellers' system of screws can be maintained if they are only made of the right pitch, and of the specified diameter on the outside and at the root of the thread; if the tool for cutting the latter is made of the proper form, and if the thread is cut so that the flat at the point and root are equal. This is true if all these operations are performed with the requisite degree of precision, but though it would be interesting to describe all the processes and instruments which are used in making taps, dies, and screw-gauges, a brief general description is all that can be given within the limits of space.

The first step in making a tap or screw-gauge is to turn a bar of steel to the exact diameter of the outside of the screw. Then one end of the portion on which the thread is to be cut

is turned down to the diameter of the screw at the root of the thread. On the exactness of this first operation, the precision of the ultimate size will depend. It is, therefore, essential to be able to measure exactlv these two diameters.

The next step is to cut the thread. To do this a tool must be ground, which will cut a thread whose sides will have an angle of exactly 60deg. to each other. An amount equal to one-eighth of the pitch must be taken off the point of the tool, the flat portion being true to the sides of the thread. To make a true thread the tool must then be set so that its centre line will be square with the axis of the screw. In order to be able to do this, the sides of the tool are ground so as to be true parallel planes, and the parts which cut the sides of the thread are ground so as to be true with the sides of the tool and at an angle of 60deg. to each other. It can then be set true in a lathe, with a try-square bearing against its sides. What adds to the difficulty though, is the fact that a cutting tool of this kind does not stand vertically, but at an angle to a perpendicular line, while the top surface is horizontal. Now if the portions of the tool which conform to the sides of the thread were ground with an angle of 60deg. to each other, the edges of a plane which intersects these sides at an angle of more or less than 90deg. would not be inclined at an angle of 60deg. to each other. For this reason the tool must be ground at an angle of somewhat greater than 60deg., so that the cutting edges formed by the intersection of the flat top surface and the inclined edges of the tool will be exactly 60deg. If the clearance angle be 20deg., the actual angle between the sides of the threading tool will be 63deg. 8min. A delicate instrument is used to measure the exact amount, equal to one-eighth of the pitch, that should be taken off the point of the tool for cutting threads of various sizes. These processes and appliances are required to make a turning tool of the exact shape and size to cut the threads.

With such a tool and a blank cylindrical end for a gauge, such as has been described, it would seem that by cutting the thread so deep that the end of the tool would just touch that part of the blank which has been turned down to the size of

the screw at the root of the thread, the screw must be exactly the right size. If all the work described has been done with absolute precision, such will be the case; but in order to verify it, the same tool used for cutting the groove is made to cut a template in thin sheet metal. The space cut out of the sheet metal will, of course, be an exact duplicate of the space between the threads. As the space between the threads should be an exact counterpart of the thread itself, the latter can be measured by the template, and if they exactly correspond, it will indicate that all the operations have been performed with the required precision, and the screw thus made supplies a true gauge to work to. It should be kept in mind that the *sides* of the threads of a screw are, or should be, the actual bearing surfaces, and that in making taps and dies the threads should be measured over the sides. With such a gauge as will be supplied by the screw described, it is an easy matter to set an ordinary pair of callipers over the sides of the threads, and then reproduce that size in any number of other screws or taps.

But there is still another difficulty. If made as described, the steel must be soft, and it is therefore requisite that taps should be hardened. The process of doing so, however, changes their form and dimensions slightly so as to impair their accuracy. To get over this difficulty in the case of gauges, these, when intended to be hardened for working gauges, are made somewhat larger than standard size. A plan has been devised to grind these gauges, after they are hardened, to the exact size, form, and pitch. To do this a rapidly-revolving steel disc or wheel is attached to the tool-holder in the slide-rest, which is moved by the leading screw at a rate exactly equal to that of the screw of the gauge. Diamond dust is used on this disc for grinding the hardened threads, and the exact size is reproduced from a soft gauge, whose dimensions have not been changed by hardening.

Gauges suited for workshop use to secure uniformity of size in bolts and screw-threads are very easily made by tapping a few nuts with a new tap of accurate size; these nuts can be used as shop gauges by the workmen. When

worn they can be replaced by new nuts cut with other new taps, or with other nuts cut with the first-named tap and stored away till wanted. In respect of the accuracy required to give good fits, it may be noted that a difference of two-thousandths of an inch from the exact size will suffice to make a "loose fit" of a ¾in. bolt and nut.

Smaller screws, which term is intended to comprise those under ¼in. diameter, are not properly represented in either of the two systems mentioned. Quite recently several attempts have been made to systematise the screws for use in horological, electrical, and similar instruments. Prof. Thury, of Geneva, having collected and measured a large quantity of screws used in scientific instruments, and considered to be well proportioned, tabulated the dimensions given on pages 47 and 48 (see Chap. IV.). The thread adopted is triangular, the two sides embracing an angle of 47½deg. The top of the thread is rounded off by a radius of one-sixth the pitch, and the groove is rounded by a radius of one-fifth the pitch of the thread. The depth of the thread is three-fifths of the pitch. The whole of this system of screws is based on No. 0, which is 6mm. = ·236in. diameter, its pitch is 1mm. = ·039in. Each succeeding screw has its pitch nine-tenths of the next larger, a very simple ratio. The pitches of these small screws are seldom accurate in practice, for when cut with screw plates, or even with dies, it often happens that several screws made with the same screwing-tackle differ from each other. The British Association formed a committee in 1881 to determine a gauge for the various small screws used in telegraphic and electrical apparatus, in clockwork, and for analogous purposes (see Chap. V.). That committee recommended the threads as tabulated by Prof. Thury, but rounded alike top and bottom. The unit of measurement adopted being the millimètre; a complete table of change-wheels required for cutting millimètre pitches, with guide-screws of ½in. and ¼in. pitch, is given in Chap. X.

For ready comparison the thread-forms of Whitworth, Fig. 15, American, Fig. 16, Swiss, Fig. 17, and Steinlen, Fig. 18, are here illustrated together. They are each drawn to exact

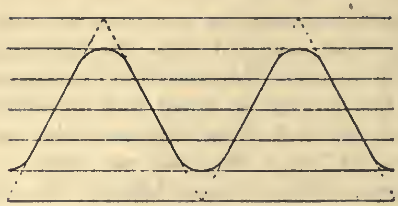

FIG. 15. WHITWORTH THREAD-FORM.

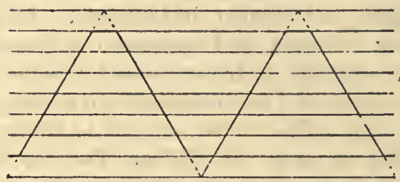

FIG. 16. AMERICAN THREAD-FORM.

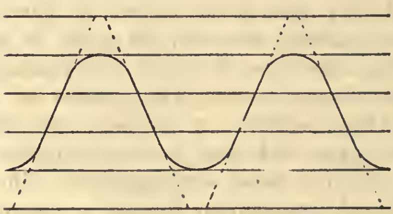

FIG. 17. SWISS THREAD-FORM.

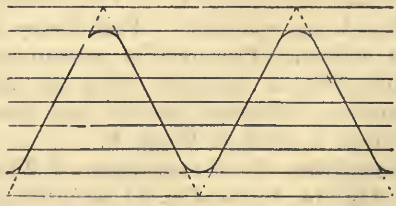

FIG. 18. STEINLEN THREAD-FORM.

scale, and all are the same pitch, viz., 1in. The relative depths and strengths of these different thread-forms are easily seen here, and the details of their various dimensions will be found in later chapters.

In Chap. X. will be found the most extensive tables of standard screw-threads hitherto published, and also in Chap. XIII. many other tables of great use to those who are interested in screws and screw-making.

CHAPTER II.

WHITWORTH'S SYSTEM OF SCREWS.

IN 1841 the late Sir Joseph (then Mr.) Whitworth made a communication to the Institution of Civil Engineers on a uniform system of screw-threads as follows:

The screw-threads which form the subject of this paper are those of bolts and screws used in fitting up steam engines and other machinery. Great inconvenience is found to arise from the variety of threads adopted by different manufacturers. The general provision for repairs is rendered at once expensive and imperfect. The difficulty of ascertaining the exact pitch of a particular thread, especially when it is not a sub-multiple of the common inch measure, occasions extreme embarrassment. This evil would be completely obviated by uniformity of system, the thread becoming constant for a given diameter. The same principle would supersede the costly variety of screwing apparatus, required in many establishments, and remove the confusion and delay occasioned thereby. It would also prevent the waste of bolts and nuts which is now unavoidable. The impulse and direction given to machinery during late years have tended to increase these evils, and must ultimately lead to a change of system. Take, for example, the re-fitting shop of a railway or steam packet company. Here the variety of apparatus rendered necessary by the want of uniformity will correspond with the number of distinct manufacturers by whom the engines are supplied, whereas, if the same system of screw-threads were common to the different engines, a single set

of screwing tackle would suffice. The economy and manifold advantage resulting from uniformity in this instance must be sufficiently obvious.

Supposing the same principle extended throughout engineering and other establishments until its application became general, the advantage would be proportionately greater, and would assume a character of public importance. Public convenience would be promoted in various ways easy to trace, though leading to results perhaps little expected, and the economy of screwing apparatus, however considerable, would become insignificant when compared with the contingent benefit to other interests.

Were a uniform system adopted for marine or locomotive engines there can be no doubt that it would be extended to engines and machinery of almost every description. Peculiar threads will, of course, be always required for particular purposes, but in screws for general use in fitting up machinery, the advantage of uniformity would be paramount to every other consideration.

It does not appear that any combined effort has been hitherto made to attain this object. As yet there is no recognised standard. This will not be matter of surprise, when it is considered that any standard must be to a great extent arbitrary. It is impossible to deduce a *precise* rule from mechanical principles, or from any number of experiments. On the other hand, the nature of the case is such that mere approximation would be unimportant, absolute identity of thread being indispensable.

To how great an extent the choice of thread is arbitrary will appear from a cursory consideration of the principles affecting it. Without attempting to discuss these in detail, which would be foreign to the present purpose, it may be interesting to notice the general outline and bearings of the subject.

The use of the screw-bolt is to unite certain parts of machinery in close and firm contact. It is peculiarly adapted for this purpose by the compact form in which it possesses the necessary strength and mechanical power. The extreme

familiarity of the object tends to prevent the observation of its peculiar fitness. Yet among all the applications of mechanics there is, perhaps, no instance of adaptation more remarkable. The ease with which distinct parts of machinery can be united, the firmness with which they are held together, and the facility with which they may be separated, are conditions of the utmost importance, which by no other contrivance could be combined in an equal degree.

While, however, the utility of the screw in this application is abundantly obvious, it is by no means evident what may be the precise formation most advantageous under all circumstances. No exact data of any kind can be obtained for calculation, and the problem will be found to be capable only of approximate solution.

The principal conditions required in the screw-bolt are power, strength, and durability—the latter having reference to the wear occasioned by frequent fixing and unfixing. But none of these conditions can be reduced to a definite quantity. We cannot, for example, determine the exact amount of power necessary to draw the parts of a machine into due contact, or the precise degree of strength which may suffice for resisting the strains to which they may be afterwards exposed. Hence we cannot lay down any rule for choosing the diameter of the screw-bolt required for a given purpose. Practical men can judge of the proper size with considerable nicety, but they have no means of ascertaining it with absolute precision.

If the diameter be given, and it be required to find the proper thread, the nature of the question is not essentially altered. The amount neither of power nor of strength (nor any other condition) is thereby determined. A certain limit is assigned, but within that limit the proportions of strength, power, &c., may vary indefinitely, according to the actual formation of the thread.

There are three essential characters belonging to the screw-thread, viz., pitch, depth, and form. Each of these may be indefinitely modified independently of the others, and any change will more or less affect the several conditions of

power, strength, and durability. The mechanical power of the screw depends on the pitch, which, for a given diameter, determines the angle of the inclined plane, and on the form of thread which regulates the direction in which the force applied will act. The strength of the screw in the thread varies with each of the three characters; in the centre part, being as the area, it is little affected, except by change of depth. The durability of the thread also depends chiefly on its depth, and the proper degree of the latter is determined principally with reference to this condition. In the selection of the thread considerable latitude of choice will be found to prevail with reference to all the characters. No definite rule can be given for determining any one of them. It may be manifest that particular threads are too coarse or too fine, too deep or too shallow; but there are intermediate degrees within which the choice of thread, like that of the diameter, is arbitrary, and must be guided rather by discretion than by calculation.

The mutual dependence of the several conditions required in the thread may be noticed as having a tendency to perplex the choice. Thus, increase of power is necessarily attended with diminution of strength. The square thread, which has the advantage in respect of power, is proportionally weaker than the angular thread. A fine thread loses in strength, while it gains mechanically as compared with a coarser. Deep threads, also, while they are more durable than shallow, materially detract from the strength of the bolt.

The selection of the thread is also affected by the mutual relation subsisting between the three constituent characters of pitch, depth, and form. Each of these, as before observed, may be separately modified; but practically no one character can be determined irrespective of the others. The pitch of the square thread is generally twice that of the angular for the same diameter, to retain similar proportions of power and strength. Coarse threads should be deep as compared with fine, to provide against the wear from friction. A coarse angular thread will also require additional depth to preserve the due proportion of power, and to prevent the longitudinal

strain from being thrown too much sideways on the nut. Hence, each character acts as a limit to the variation of the others, and in some instances (that is, in the case of certain diameters) it will be found that the leading consideration in fixing one character is the resulting effect on another. Thus, in some of the smaller sizes, the pitch is determined principally by reference to the depth—a coarser thread being objectionable, because the extra depth would too much weaken the centre part of the bolt—while the necessary shallowness of a finer thread would render it too liable to wear with friction.

The proportionate strength of the thread and centre part of the screw is regulated mainly by the depth of the nut, which is generally of the same measure as the diameter of the bolt. Assuming this dimension as fixed, the proportion of strength between the two parts will vary with the different characters of thread, and more particularly with the depth. The centre part not being liable to wear, while the thread is subject to friction and accidental injury, the original proportion of strength ought to be considerably in favour of the latter.

Such being the variety and vagueness of the principles involved in the subject, a corresponding latitude might naturally be expected in their practical application, and accordingly we find, instead of that uniformity which is so desirable, a diversity so great as almost to discourage any hope of its removal. The only mode in which this could be attempted with any probability of success would be by a sort of compromise, all parties consenting to adopt a medium for the sake of common advantage. The average pitch and depth of the various threads used by the leading engineers would thus become the common standard, which would not only have the advantage of conciliating general concurrence, but would, in all probability, be nearer the true standard for practical purposes than any other.

Messrs. Whitworth and Co. were led some years ago to alter the threads of their screwing-tackle on this principle, in consequence of various objections urged against those they

had previously adopted, and the result of the experiment has been abundantly satisfactory. An extensive collection was made of screw-bolts from the principal workshops throughout England, and the average thread was carefully observed for different diameters. The ¼in., ½in., 1in., and 1½in. were particularly selected and taken as the fixed points of a scale by which the intermediate sizes were regulated. The only deviation made from the exact average was such as might be necessary to avoid the great inconvenience of small fractional parts in the number of threads to the inch. The scale was afterwards extended to six inches.

The pitches thus obtained for angular threads are shown in tables printed in Chap. XIII.

It will be observed that above 1in. diameter the same pitch is used for two sizes. This could not have been avoided without introducing small fractional parts. The economy of screwing apparatus was also promoted by repetition of the thread.

It is important to remark that the proportion between the pitch and the diameter varies throughout the entire scale. Thus, the pitch of the ¼in. is one-fifth of the diameter—that of the ½in., one-sixth—of the 1in., one-eighth—of the 4in., one-twelfth—of the 6in., one-fifteenth. It is obvious that more power is required as the diameter increases. But this consideration alone will not account for the actual deviation, which is much less than it would be if the scale were calculated with reference to the power required. The amount of power necessary must be determined in relation to the muscular force of the human arm, aided by the leverage of the screw-key. Now, in the case of smaller screws, there is a considerable excess of force, and consequently of power. Again, in the larger, there will be found a deficiency of power, for, with all the leverage which can generally be applied, it requires the force of several men to fix a bolt of 6in. diameter. Hence it is evident that, at the two extremes of the scale, the amount of power required is not the leading consideration in fixing the pitch of the thread. In the smaller sizes, the necessary depth

every part, and coalesce throughout their whole depth, their mutual action is completely deranged, strength are both sacrificed, and friction is pro- increased. The immense consumption of bolts and ting up and working machinery may give some idea ent to which greater accuracy might be productive y.

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CHAPTER III

AMERICAN SYSTEM OF SCREWS.

IN 1864 a special committee was appointed by the Franklin Institute, of the State of Pennsylvania, U.S.A., for the promotion of the mechanic arts, to investigate the question of the proper system of screw-threads, bolt-heads, and nuts, to be recommended by the Institute for adoption by American engineers.

The report of this committee states: That in the course of their investigations they have become more deeply impressed with the necessity of some acknowledged standard, the variation of threads in use being much greater than they had supposed possible; in fact, the difficulty of obtaining the exact pitch of a thread not a multiple or a sub-multiple of the inch measure, is sometimes a matter of extreme embarrassment. Such a state of things must evidently be prejudicial to the best interests of the whole country—a great and unnecessary waste is its certain consequence; for not only must the various parts of new machinery be adjusted to each other in place of being interchangeable, but no adequate provision can be made for repairs, and a costly variety of screwing apparatus becomes a necessity. It may reasonably be hoped that should a uniformity of practice result from the efforts and investigations now undertaken, the advantages arising from it will be so manifest as to induce reform in other particulars of scarcely less importance.

Numerous meetings have been held for the purpose of considering the various conditions required in any system which

respond in every part, and coalesce throughout their whole length and depth, their mutual action is completely deranged, power and strength are both sacrificed, and friction is proportionally increased. The immense consumption of bolts and nuts in fitting up and working machinery may give some idea of the extent to which greater accuracy might be productive of economy.

It is intended on a future occasion to enter more particularly into the subject of screwing-tackle, when it will appear that there are ample means for attaining the requisite degree of accuracy in ordinary practice.

To maintain uniformity, provision must be made for multiplying standards of the diameters and threads. Without a particular provision of this kind, which, as will be shown hereafter, may be easily made, the screwing-tackle would degenerate by use and propagation.

This part of the case is connected with a subject of great extent which, under every aspect, lays claim to the attention of practical engineers. We allude to the general use of standard gauges, graduated to a fixed scale, as constant measures of size. It is quite practicable by such means to work to a common measure with a degree of accuracy sufficient for all ordinary purposes. Corresponding parts, instead of being got up one to another, might be prepared separately. The indefinite multiplication of sizes would thus be prevented, and the economy of the workshop simplified to an extent beyond calculation.

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Numerous meetings have been held for the purpose of considering the various conditions required in any system which

your committee could recommend for adoption. Strength, durability, with reference to wear from constant use and ease of construction. would seem to be the principal requisites in any general system; for although in many cases, as, for instance, when a square thread is used, the strength of the thread and bolt are both sacrificed for the sake of securing some other advantage, yet all such have been considered as special cases, not affecting the general inquiry. With this in view, your committee decided that threads having their sides at an angle to each other must necessarily more nearly fulfil the first condition than any other form; but what this angle should be, must be governed by a variety of considerations, for it is clear that if the two sides start from the same point at the top, the greater the angle contained between them, the greater will be the strength of the bolt; on the other hand, the greater this angle, supposing the apex of the thread to be over the centre of its base, the greater will be the tendency to burst the nut, and the greater the friction between nut and bolt, so that, if carried to excess, the bolt would be broken by torsional strain rather than by strain in the direction of its length. If, however, we should make one side of the thread perpendicular to the axis of the bolt, and the other at an angle to the first, we should obtain the greatest amount of strength, together with the least frictional resistance; but we should have a thread only suitable for supporting strains in one direction, and constant care would be requisite to cut the thread in the nut in the proper direction to correspond with the bolt. We have consequently classed this form as exceptional, and decided that the two sides should be at an angle to each other and form equal angles with the base

The general form of thread having been determined upon the above considerations, the angle which the sides should bear to each other has been fixed at 60deg., not only because this seems to fulfil the conditions of least frictional resistance combined with the greatest strength, but because it is an angle more readily obtained than any other, and it is also in

more general use. As this form is in common use, almost to the exclusion of any other, your committee have carefully considered its advantages and disadvantages before deciding to recommend any modification of it. It cannot be doubted that the sharp thread offers us the simplest form, and that its general adoption would require no special tools for its construction, but its liability to accident, always great, becomes a serious matter upon large bolts, whilst the small amount of strength at the sharp top is a strong inducement to sacrifice some of it for the sake of better protection to the remainder. When this conclusion is reached, it is at once evident a corresponding space may be filled up in the bottom of the thread, and thus give an increased strength to the bolt, which may compensate for the reduction in strength and wearing surface upon the thread. It is also clear that such a modification, by avoiding the fine points and angles in the tools of construction, will increase their durability; all of which being admitted, the question comes up: What form shall be given the top and bottom of the thread? for it is evident that one should be the converse of the other. It being admitted that the sharp thread can be made interchangeable more readily than any other, it is clear that this advantage would not be impaired if we should stop cutting out the space before we had made the thread full or sharp; but to give the same shape to the bottom of the thread would require that a similar quantity should be taken off the point of the cutting-tool, thus necessitating the use of some instrument capable of measuring the required amount; but when this is done the thread having a flat top and bottom can be quite readily formed as if it were sharp. A very slight examination sufficed to satisfy your committee that, in point of construction, the rounded top and bottom presents much greater difficulties; in fact, all taps and screws that are chased or cut in a lathe required to be finished or rounded by a second process. As the radius of the curve to form this must vary for every thread, it will be impossible to make one gauge to answer for all sizes, and very difficult, in fact impossible without special tools, to shape it correctly for one.

Your committee are of opinion that the introduction of a uniform system would be greatly facilitated by the adoption of such a form of thread as would enable any intelligent mechanic to construct it without any special tools, or, if any are necessary, that they shall be as few and as simple as possible, so that, although the round top and bottom presents some advantages when it is perfectly made, as increased strength to the thread and the best form to the cutting-tools, yet we have considered that these are more than compensated by ease of construction, the certainty of fit, and increased wearing surface offered by the flat top and bottom, and, therefore, recommend its adoption. The amount of flat to be taken off should be as small as possible, and only sufficient to protect the thread; for this purpose one-eighth of the pitch would seem to be ample, and this will leave three-fourths of the pitch for bearing surface. The considerations governing the pitch are so various that their discussion has consumed much time.

As in every instance the threads now in use are stronger than their bolts, it became a question whether a finer scale would not be an advantage. It is possible that if the use of the screw-thread were confined to wrought-iron or brass, such a conclusion might have been reached; but as cast-iron enters so largely into all engineering work, it was believed finer threads than those in general use might not be found an improvement, particularly when it was considered that, so far as the vertical height of thread and strength of bolt are concerned, the adoption of a flat top and bottom thread was equivalent to decreasing the pitch of a sharp thread 25 per cent., or, what is the same thing, increasing the number of threads per inch 33 per cent. If finer threads were adopted they would require also greater exactitude than at present exists in the machinery of construction, to avoid the liability of over-riding, and the wearing surface would be diminished; moreover, we are of opinion that the average practice of the mechanical world would probably be found better adapted to the general want than any proportions founded upon theory alone.

We have taken some pains to ascertain what the proportions in use are, and submit the following, as being in our judgment a fair average, viz.:

Diameter of Bolt	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$
No. threads per inch.	20	18	16	14	13	12	11	10	9	8	7	7
Diameter of Bolt.	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$
No. threads per inch.	6	6	$5\frac{1}{2}$	5	5	$4\frac{1}{2}$	$4\frac{1}{2}$	4	4	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{4}$
Diameter of Bolt.	$3\frac{3}{4}$	4	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	5	$5\frac{1}{4}$	$5\frac{1}{2}$	$5\frac{3}{4}$	6.		
No. threads per inch.	3	3	$2\frac{7}{8}$	$2\frac{3}{4}$	$2\frac{5}{8}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{3}{8}$	$2\frac{3}{8}$	$2\frac{1}{4}$.		

The proportions for bolt-heads and nuts, as given in most of our books of reference, are believed to be larger than necessary, and all are tabulated necessitating constant reference. A simple formula would be more convenient, and would probably induce a uniform practice; but as most of the sizes in common use are made by machinery, and also by hand, it is believed the bolt-head and nut for finished work should be made somewhat smaller than for rough, to avoid the confusion that would ensue if the necessary allowance for dressing should be made upon work intended for finishing.

In conclusion, therefore, your committee offer the following: That the Franklin Institute of the State of Pennsylvania recommend, for general adoption by American engineers, the following forms and proportions for screw-threads, bolt-heads, and nuts, viz.:

That screw-threads shall be formed with straight sides at an angle to each other of 60deg., having a flat surface at the top and bottom equal to one-eighth of the pitch. The pitches shall be as tabulated above.

The distance between the parallel sides of a bolt-head and nut for a rough bolt shall be equal to one and a-half diameters of the bolt plus one-eighth of an inch. The thickness of the heads for a rough bolt shall be equal to one-half

the distance between its parallel sides. The thickness of the nut shall be equal to the diameter of the bolt. The thickness of the head for a finished bolt shall be equal to the thickness of the nut. The distance between the parallel sides of

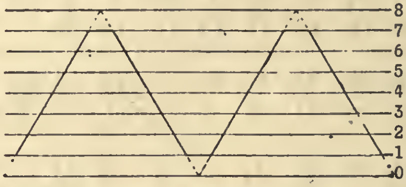

FIG. 20. DIAGRAM OF AMERICAN THREAD.

a bolt-head and nut, and the thickness of the nut, shall be one-sixteenth of an inch less for finished work than for rough.

[NOTE.—It will be obvious that the above report left some serious points open to misconstruction and doubt, and as a fact carrying out the recommendations contained in it led to further confusion which the master car-builders determined to investigate. Their report, somewhat abridged, is as follows.]

REPORT OF THE MASTER CAR-BUILDERS' COMMITTEE.

The Master Car-Builders' Association appointed a committee to investigate and report on the present construction of screws and nuts used in cars; and the amount of accuracy that is desirable to secure, and the best means of maintaining it in the standard adopted by the Association (that is, the Franklin Institute standard), and to draw up communications addressed to the managers and superintendents of railroads, showing the necessity for the use of even sizes of screw-threads, and the amount of savings, as near as can be estimated, that will result to the roads by strictly adhering to this practice.

The report of this committee was made in 1882, after having had the subject under consideration for several years. It discusses minutely many of the details connected with

various inquiries made, and gives much matter not essential to the immediate object of this book, making the report too long for reproduction here entire. The salient points are, however, all contained in the following abridgment:

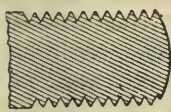

FIG. 21.
SHARP V-SCREW.

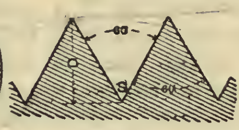

FIG. 22.
SHARP V-THREAD.

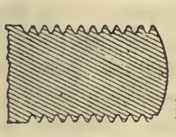

FIG. 23.
WHITWORTH'S SCREW.

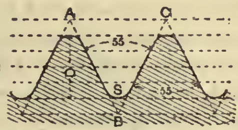

FIG. 24.
WHITWORTH'S THREAD.

FIG. 25.
SELLERS' SCREW.

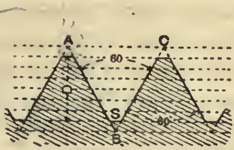

FIG. 26.
SELLERS' THREAD.

A brief historical review of what has been done is requisite. In 1864 the inconvenience and confusion resulting from the diversity in the screw-threads used in machine and other construction was brought before the Franklin Institute of Philadelphia. A committee was appointed to investigate and report on the subject. That committee recommended the system designed by Mr. William Sellers, and the Institute afterwards adopted their recommendation. Practically, the three systems from which they were obliged to choose were, the ordinary sharp V-thread shown in Figs. 21 and 22.

The Figs. to the left represent sections of an inch bolt half size, and the Figs. to the right sections of the threads enlarged four times their actual size. Figs. 23 and 24 show Whitworth's thread, and Figs. 25 and 26 Sellers' system. The angle contained between the sides of the V is generally 60deg., although it is not uniformly so; when it is, the depth D from the root of the thread to the point is slightly less than $\frac{7}{8}$ of the pitch. In the Whitworth thread the depth D is $\frac{2}{3}$ of the pitch, and the top and bottom of the threads are then rounded as shown. The angles of the sides of the threads to each other are 55deg.

The objections to the V-thread are that the point or outer edge of the thread is sharp, and therefore very frail and liable to injury from contact with other objects. The space S, or groove between the threads at the root, is also sharp, which facilitates fracture under strain, and is a source of weakness in the screw. The depth D of the V-thread, being slightly greater than that of the Whitworth thread, the effective diameter of the screw, at the root of the thread, is materially less in the former than in the latter.

In Figs. 24 and 26 the contour of the thread is shown by the dotted lines AB and CB. It will be seen that if a V-thread is used instead of the Whitworth or Sellers, the former would cut into the bolt farther, by a distance represented by SB, than the others do.

The objections to the Whitworth thread are that the angle of 55deg. cannot be measured or laid off with ordinary tools, and that the rounded corners at the point and root of the threads are extremely difficult to produce with any degree of precision in the tools required to make screws. These considerations led Mr. Sellers to design the system of threads the form of which is shown by Figs. 25 and 26. In this the angle of the V-thread (60deg.) is retained, but instead of rounding the point and root these are made flat, one-eighth of the depth of the thread being taken off at the top and one-eighth at the bottom, which leaves the depth of the thread somewhat less than two-thirds of the pitch. This leaves the effective diameter of the bolts somewhat greater even than

that of the Whitworth thread. The flat top and bottom in screw-making tools can be easily and accurately made, and the angle of the thread can be produced simply by laying off a triangle having equal sides, or sub-dividing the circumference of a circle with its own radius, and drawing lines from adjacent points of sub-division to the centre. The difference in the effective diameter of the Whitworth and Sellers' systems of course gives them greater strength to resist tension and torsion than screws with V-threads of 60deg. have. It is true that the V-thread might be made with sides having a more obtuse angle to each other, but in that case the nuts would be subjected to greater strain.

The difference in the resistance to tension and torsion of bolts with Sellers' threads compared with those having V-threads was calculated. The data of this table may be approximately summed up by stating that the smaller bolts, with the Sellers' thread, have about a *quarter* more strength, the medium-sized ones a *sixth* more, and the larger ones an *eighth* more strength to resist tension than screws, having an ordinary V-thread. The resistance to torsion of screws with the Sellers' thread is about a *third*, a *quarter*, and a *fifth* greater, respectively, than those with a V-thread.

The advantages of the Sellers' thread were recognised, and its use was authorised for the naval service and recommended for general use in locomotive construction and for cars.

Unfortunately, though, when this was done, a large proportion seemed to have the impression that the Sellers' system consists simply in a standard for the number of threads to the inch, and apparently not sufficient effort has been made to impress the fact on the minds of those who have the control of such matters that *three* features are essential to the Sellers' system:

First.—Screws must have a given number of threads per inch.

Second.—The threads must be of the form and proportions designated.

Third.—The diameters of the screws must conform to the sizes specified.

A screw which does not conform to the Sellers' system in all *three* particulars has not a legitimate Sellers' thread. All screws with a number of threads per inch different from those given in the table (see Chap. XIII.), do not agree with the requirements of the Sellers' system. But, even if the number of threads per inch is right, if the *shape* of the thread is different from that specified (see illustration, page 32), it is not a Sellers' screw. It is just as much a bastard screw if the thread is made V-shaped and the pitch right as though the pitch was wrong and the shape of the thread right.

A screw with a Sellers' thread must be of one of the diameters given in the table (Chap. XIII.). There are no other sizes in the system. There is no such thing, for example, as a Sellers' screw $\frac{3}{4}$in. and $\frac{1}{32}$in. in diameter. That size is not recognised and has no existence in the system; and if a screw is made, as is often done, $\frac{3}{4}$in. in diameter "a sixty-fourth" or "a thirty-second" large, it ceases to be a Sellers' screw. Uniformity in diameter is as essential to interchangeability as uniformity in the number of threads per inch, or the shape of the threads. Just as soon as the practice is introduced of making screws "over size," or "a sixty-fourth" or "a thirty-second" large, interchangeability of bolts and nuts becomes impossible. If the Sellers' standard is adopted, no screws should be tolerated which are a fraction of an inch larger or smaller than the diameter specified for that system.

But while the form, proportions, and dimensions of the standard screw-threads were as definitely fixed by Mr. Sellers and the action of the Franklin Institute as it is possible for them to be, and although it was thus made plain what the standard screws *should* be, subsequent experience showed that it was not so easy as it appeared to make them conform, with a sufficient degree of precision for practical purposes, to the requirements laid down by Mr. Sellers.

The difficulty was very well described by the following statement: In 1874 the Sellers' system was adopted on the Erie Railroad, and a set of standard taps and dies had been furnished to each of the shops on that line, which, as they wore out, were replaced by others made from the originals at

each of the shops. In 1876 attention was called to the fact that some nuts cut at one shop would not fit bolts cut at others, and an investigation was made. A set of nuts of the different sizes were cut at each of the shops and these were fitted with soft Babbit-metal plugs. By taking at random a plug and a nut of nominally the same diameter it was found that the one would rarely fit the other. It was seen that not only were the diameters different, but in many cases the pitch and angle of the threads had been altered from the original standard, and the taps made at different shops did not conform to each other. Nuts were taken from twenty-three or twenty-four cars, not home made, and these were not only unlike the home screws, but were also unlike each other. It was found, moreover, that the practice had generally obtained of making taps over size, so that all bolts above $\frac{5}{8}$in. in diameter were $\frac{1}{64}$in. and the smaller bolts $\frac{1}{32}$in. over size. Investigation showed that the company was paying for about 35,000lb. of iron more than would have been required if it had been furnished to exact sizes. Instructions were therefore given that no more taps and dies should be made at the various shops, and since then all these tools have been bought from manufacturers of them, at considerably less cost than they could be made for in the company's shops. It was supposed that in this way absolute uniformity could be obtained. Taps were, however, bought of different manufacturers, and it was found that some of the nuts cut with taps bought of one manufacturer could not be screwed on a tap made by another, and although the difference was not very great it was sufficient to prevent the bolts and nuts from interchanging with each other. Subsequent inquiry elicited the fact that the manufacturers of taps and dies had been working to different standards of length, and as neither the inch nor the gauge were known to be accurate measures it is not remarkable that bolts and nuts cut with tools made by different manufacturers were not interchangeable.

To test the various measures used, and to determine which was correct, was the next step. The most reliable standards of measurement were procured from different sources, and it

was found that no two agreed! These same standards were then measured by what were considered the most reliable measuring machines and instruments in the United States, and it was found that no two of these would measure the same standard alike! To be brief, the results of these investigations made it doubtful whether there was any final standard of length in the country, or any instruments for measuring and sub-dividing the standard, if it existed, which could be relied upon to give results which would be at all satisfactory.

The matter was of great importance in the manufacture, not only of taps and dies, but of other tools, gauges, and instruments of precision, and the Pratt and Whitney Company, of Hartford (U.S.A.), determined to go to the bottom of the subject and lay a foundation against which no wind or wave of doubt or uncertainty could prevail. It will, however, be impossible to give here a description of the methods employed to secure the utmost precision.

The number of threads per inch for any required diameter of screw or bolt in the United States series may be definitely fixed by the following empirical formula, which serves to determine, independently of tables or other aids, the correct pitches for any diameter of bolt, and is

$$p = \frac{\sqrt{d - a}}{c},$$

in which $d =$ the number of sixteenths in the diameter of the bolt + 10; $a = 2{\cdot}909$; $c = 16{\cdot}64$; and $p =$ pitch of the thread. A simpler and more convenient form of this equation, and one which is readily deduced from it, is

$$p = 0{\cdot}24 \sqrt{\mathrm{D} + 0{\cdot}625} - 0{\cdot}175$$

in which D represents the diameter of the bolt or screw in inches.

To illustrate the use of this formula take, for example, a 2in. bolt and let it be required to determine the pitch of

the thread and the number of threads per inch. Making the proper substitution for D, the formula becomes:

$$\begin{aligned} p &= 0{\cdot}24\ \sqrt{2 + 0{\cdot}625} - 0{\cdot}175 \\ &= 0{\cdot}24\ \sqrt{2{\cdot}625} - 0{\cdot}175 \\ &= 0{\cdot}24 \times 1{\cdot}62 - 0{\cdot}175 \\ &= 0{\cdot}2138 \text{ of an inch.} \end{aligned}$$

The reciprocal of this, or $\frac{1}{0{\cdot}2138} = 4{\cdot}68$, gives the proper number of threads per inch. For the purpose of avoiding the use of troublesome fractions, the nearest convenient aliquot, or $4\frac{1}{2}$, is taken. This will be found to correspond with the number of threads given in the table. This latter provision is designed to avoid the necessity for complicated screw-cutting gearing, by preventing, as far as possible, the use of fractional threads.

The formula from which is derived the correct diameter of United States standard bolts at the bottom of the thread, that is the exact diameter of the whole for tapping with no allowance for clearance, is as follows:

$$d = \mathrm{D} - \frac{1{\cdot}2990381}{\text{No. of threads per in.}}$$

In which d = the diameter at the root of the thread, and D the diameter of the outside of the thread of bolt or screw. It is, however, usual to allow from 0·004in. for $\frac{1}{4}$in. to 0·01in. for 2in. taps in excess of these diameters for actual workshop practice in tapping.

The width of flat for any number of threads per inch is one-eighth the pitch, or

$$\mathrm{W} = \tfrac{1}{8}\left(\frac{1}{\text{No. of threads per in.}}\right).$$

A modification of the formula constructed by Sellers for determining the pitch of United States standard screws, to make it applicable to threads which are smaller than $\frac{1}{4}$in.

diameter, has been proposed, and met with general acceptance. This is to change the co-efficient 0·24 to 0·23, which increases the number of threads per inch more rapidly as the diameter decreases, thus:

$$p = 0{\cdot}23\sqrt{D + 0{\cdot}625} - 0{\cdot}175.$$

This formula is proposed to be applied to the pitches of small screws when finer threads are desirable, and with the United States form of thread it gives for sizes below $\frac{1}{4}$in. a good ratio of diameter to pitch, as shown by the following table:

Diameter	$\frac{1}{16}$	$\frac{3}{32}$	$\frac{1}{8}$	$\frac{5}{32}$	$\frac{3}{16}$	$\frac{7}{32}$
Threads per inch ...	64	50	40	36	32	28

CHAPTER IV.

SWISS SYSTEM OF SCREWS.

IN 1876 the Horological Section of the Geneva Society of Arts appointed a committee to inquire into the methods by which a uniform system of screws could be determined suited to the requirements of the Horological art in Switzerland.

This committee consisted of leading men actually engaged in the manufacture of watches, clocks, musical boxes, &c., and of the tools used in these businesses. After the requirements had been fully discussed, and samples of screws then in use had been obtained, the work of analysing these latter was undertaken by Professor Thury. He then tabulated the results in a MS. volume, now in the library of the Society of Arts at Geneva. The task of reconciling the then irregular proportions of existing screws into some simple systematic relative proportions was then most successfully accomplished by Professor Thury, and the following pages give a *résumé* of his thoroughly practical observations.

The advantages that would result from diminishing the variety of types of screws commonly used in the mechanical arts are fully realised by practical men. These advantages may be summarised as follows:

Repairs are more easy of execution when the screws to be used are reduced to a small variety which, for this reason, would be more generally met with.

Special tools, such as drills, taps, screw-plates, dies, &c., diminish in cost as the number of different screws is reduced.

In the system of manufacturing separate parts confusion is less to be feared, errors are less likely to occur, and the quantity of bolts and screws required in stock is decreased as the varieties employed are reduced in number.

It would, therefore, be advantageous to determine a good selection of screw-threads, conveniently graduated, sufficiently numerous to meet the general wants of manufacture and leaving a margin for future requirements.

To this end, several systems have been proposed and used; the best known are those of Whitworth, Heilmann-Ducommun, and Steinlen, Armengaud, Bodmer, Reuleux, and Redtenbacher. Unfortunately none of these systems is applicable to screws of small dimensions employed in horological work—they give proportions and dimensions altogether inadmissible for these small screws.

Moreover, the screws generally employed in horological work are connected either in arbitrary series, more or less sanctioned by local usage but having nothing well defined, or in simple combinations, the principal defect of which is that they are applicable only to very small screws.

As there exist all intermediate dimensions between "small" and "large" screws, it follows that on the borders of these two confusion would necessarily result if two systems were used differing essentially one from the other. It would seem to be equally advantageous practically and satisfactory theoretically to combine a single system applicable to screws of all dimensions daily used in industrial arts, from the small screws used in watches to huge bolts used in big machinery. This is the problem believed to be solved for the first time.

The method of procedure in this research was as follows:

Firstly, the largest possible collection was made of known facts on screws now used in watchwork, in clockwork, in the construction of machines of all sizes, and in structural work. When these were not to be obtained, exact measurements of the screws were taken: the diameters, external and internal, the pitch and the form of thread.

This done, investigations were made to determine which system would best combine the double condition of differing

the least possible from general practice, and at the same time of giving the greatest regularity and the greatest possible theoretical simplicity, so that the whole system could be defined in very few words or by simple mathematical formulæ. This last condition is essential to avoid arbitrariness, to bring concord into the solution, and to, in some extent, do away with the personality of the author from the very nature of the question which he was called upon to solve.

Further, it is evident that concurrence would not be established amongst artisans if it were necessary that the independent approval of each should agree on a large number of details. Whilst in starting with a reasonable principle, he who would question its usefulness should first show them the generally admitted dimensions on which it is based are faulty, or else that they could be better represented by more simple formulæ than those of the System.

Definitions.—Geometrically, a screw is the union of a plane cylinder having a circular base (the core) and of a projecting ridge, of uniform shape throughout its length, wrapped on the surface of the cylinder in a regular spiral. The axis of the core is likewise the axis of the screw.

Pitch is the distance between two successive turns of the spiral ridge measured parallel to the axis of the screw. The pitch having only one dimension, the length or the size of the pitch should be spoken of.

The section of the ridge shown by a plane passing through the axis of the screw gives the generating form of the thread. Screws are termed "square-threaded" or "triangular-threaded," according as the generating form the more nearly approaches a square or a triangle. The square thread is employed for very large screws, and when the friction is required to be reduced as much as possible.

Projection or Depth of Thread is the term used for the difference between the external radius and the internal radius (or radius of the core) of the screw. The *thickness* of the thread is its dimension in the direction of the length of the screw. In triangular-threaded screws the thickness at the base is ordinarily equal to the pitch.

Inclination of the Thread is the angle formed by each of its superficial elements of depth with a plane perpendicular to the axis of the screw. This inclination increases in proportion as the axis of the screw is approached. The pitch, on the contrary, remains constant.

Rise of a screw is the proportion which exists between the length of pitch and the circumference of the screw. Rake is ordinarily expressed in hundredths of the circumference, and shows so much per cent. of slope of the inclined path.

The Nut is the solid covering of the screw, bounded by two planes perpendicular to the axis; the thickness of the nut is the distance between these two planes.

Tap is the tool used to make nuts, and *Screw-plate* is the tool used to make screws. It is correct to speak of tapping a nut and of cutting a screw.

General Proportions and Dimensions of Screws.

Succession of the Pitches in a series of Screws.—The pitches in the same series should not follow one another by equal differences—for example, by tenths in tenths of millimètres—because the series, from the longest pitches to the shortest, would at first be too slight, then would be too great, and would terminate abruptly with the pitch the length of which would be equal to the difference adopted. The most reasonable system would consist in diminishing each pitch uniformly by the same fraction of the one preceding it. In the Swiss system of screw-threads each pitch is $\frac{9}{10}$ of the preceding one, reckoning always from 1 millimètre the value of the fundamental pitch.

By numbering 1 millimètre pitch 0, the pitches numbered 1, 2, 3, 4 will be measured by the fraction $\frac{9}{10}$ taken 1, 2, 3, 4 times as factor.

The pitches larger than 1 millimètre will be obtained by continuing the series towards the left, reckoning from 1 millimètre. It suffices for this to divide each term by $\frac{9}{10}$, and the term which precedes that which is divided is obtained.

The system of numeration will be the same as in the first

case, it being only necessary to distinguish the two series, above and below, by adding to the numerals letters or signs as — or + wherever it would be possible to confuse the pitches above or below 1 millimètre.

The size of the pitches calculated by the above rules and continued decimally would be too complex for practical use. It suffices to reduce them to their two or three first significant figures. The Swiss system of screw-threads limits the selection to the first two figures. For example: Pitch No. —5, which would measure 1·6935..., is shown by 1·7, the number made by two figures most nearly approaching 1·6935.... Care must be taken not to confuse the significant figures with the decimals.

It is not advisable that successive pitches in the series should differ so little one from another to make it difficult to distinguish them by the eye alone, even in cases when each one is seen apart. This condition can be fulfilled only by diminishing a little the number of intermediate pitches now used in horological work; almost all horologists are agreed on this point. Consequently the figure diminishing the pitch in the Swiss system increases slightly the intervals; giving, for example, eleven pitches in the same range that gives fourteen in the Bourgeau scale. Moreover, the diminishing figure which gives this result suits also very well for large screws where it perceptibly follows the usual range in practice. And, further, this figure is the most simple of those which solve the problem of the intervals in a satisfactory manner.

Ratio of the Diameter of the Screw to the Length of Pitch.—The ratio of the diameter to the pitch should not be constant, on account of the difficulty of shaping very small threads exactly, and, above all, on account of the power of binding, which increases with the fineness of the pitch at the same time that the strength of the core diminishes. It is doubtless for these motives in all usual screw-cutting appliances, and in all the systems proposed for large screws, the ratio of the diameter to the pitch increases with the dimensions of the screw.

In Whitworth's system, the ratio of the diameter to the

pitch varies from 5 (in the screw of 1·27mm. pitch, ¼in. diameter) to $10\frac{1}{2}$ (in the screw of 7·2mm. pitch, 3in. diameter). In the Bourgeau scale, the same ratio varies from $5\frac{6}{10}$ (in the screw 00) to 3·0 (in the screw No. 23), and even to 2·5 (in screw No. 24). In the Latard scale, the variation is less rapid, and goes from 5·75 (in No. 1) to 4·22 (in No. 20).

In the Swiss system it has been sought not to depart from the proportions in use and sanctioned by experience, but within these limits to connect the diameter and the pitch by a mathematical relationship as simple as possible. Six millimètres has been fixed as the normal diameter for a screw of 1 millimètre pitch, and this gives the rake of this screw = 5·31, which is about $5\frac{1}{3}$ per cent.

For all other diameters of screws the diameter is obtained by multiplying by six the sum of the pitch previously raised to the power of $\frac{6}{5}$.

Relief Screws.—It is very useful for repairs to have screws of the same pitch as the ordinary screws, but slightly larger in diameter. These are called relief screws. It is proposed to make the diameters of these relief screws exactly intermediary between those of the screws of consecutive numbers.

Exceptional Screws.—Exceptional screws will be made as much as possible by combining a pitch of the system with a diameter of the system.

In the Swiss system the diameters, like the pitches, are always reduced to the first two significant figures; the second figure is increased by one when the third is 5 or more.

Formulæ.—If $\pm$ N is called the numerical order of the screw, P the pitch, D the external diameter, we shall have :

$$P = 0{\cdot}9^{n}$$
$$D = 6P^{\frac{6}{5}}.$$

These two formulæ contain the whole of the Swiss system of screws. There is besides

$$\text{Rise in hundredths } \frac{100P}{\pi D}$$

π is the ratio of the circumference to the diameter.

SWISS SYSTEM OF SCREWS,

As Tabulated by Prof. Thury, of Geneva.

No.	Absolute dimensions in millimètres.		Rise per cent.	Ratio of successive diameters.	Approximate dimensions in decimals of an inch.	
	Pitch.	External diameter.			Diameter.	Threads per inch.
25	0·0718	0·254	899	0·879	0·0100	353·70
24	0·0798	0·289	880	0·881	0·0114	318·30
23	0·0886	0·328	864	0·882	0·0129	286·65
22	0·0985	0·372	844	0·872	0·0146	255·32
21	0·109	0·426	815	0·889	0·0168	233·02
20	0·122	0·479	805	0·882	0·0189	208·19
19	0·135	0·543	791	0·882	0·0214	188·40
18	0·150	0·616	775	0·881	0·0243	169·33
17	0·167	0·699	759	0·880	0·0275	152 32
16	0·185	0·794	743	0·881	0·0313	137·29
15	0·206	0·901	728	0·883	0·0355	123 30
14	0·229	1·02	713	0·879	0·0402	110·91
13	0·254	1·16	698	0·879	0·0457	100·00
12	0·282	1·32	683	0·886	0·0520	90·07
11	0·314	1·49	669	0·909	0·0587	80·89
10	0·349	1·64	655	0·854	0·0646	72·77
9	0·387	1·92	640	0·881	0·0756	65·63
8	0·430	2·18	628	0·879	0·0858	59·06
7	0·478	2·48	615	0·883	0·0976	53·13
6	0·531	2·81	602	0·881	0·1106	47·80
5	0·590	3·19	590	0·881	0·1256	43·05
4	0·656	3·62	577	0·881	0·1425	38·71
3	0·729	4·11	565	0·882	0·1618	34·84
2	0·810	4·66	553	0·881	0·1835	31·35
1	0·900	5·29	542	0·882	0·2083	28·22
0	1·	6·	531	0·881	0·2362	25·40

SWISS SYSTEM OF SCREW-THREADS—*continued.*

No.	Absolute dimensions in millimètres.		Rise per cent.	Ratio of successive diameters.	Approximate dimensions in decimals of an inch.	
	Pitch.	External diameter.			Diameter.	Threads per inch.
- 1	1·11	6·81	519	0·881	0·2681	22·85
- 2	1·23	7·73	509	0·881	0·3043	20·65
- 3	1·37	8·77	498	0·881	0·3453	18·54
- 4	1·52	9·95	488	0·880	0·3917	16·73
- 5	1·69	11·3	478	0·883	0·4449	15·02
- 6	1·88	12·8	468	0·883	0·5039	13·48
- 7	2·09	14·5	458	0·879	0·5709	12·15
- 8	2·32	16·5	448	0·882	0·6496	10·94
- 9	2·58	18·7	439	0·882	0·7362	9·84
- 10	2·87	21·2	430	0·880	0·8346	8·85
- 11	3·19	24·1	421	0·880	0·9488	7·97
- 12	3·54	27·4	412	0·884	1·0787	7·17
- 13	3·93	31·0	403	0·881	1·2048	6·46
- 14	4·37	35·2	395	0·880	1·3858	5·81
- 15	4·86	40·0	385	0·881	1·5748	5·22
- 16	5·40	45·4	379	0·882	1·7874	4·84
- 17	6·00	51·5	371	0·882	2·0276	4·23
- 18	6·66	58·4	363	0·881	2·2992	3·82
- 19	7·40	66·3	356	0·882	2·6103	3·43
- 20	8·23	75·2	348		2·9607	3·08

The calculation should be made exact, and afterwards the final result is confined to the first two significant figures. For example, the diameter is calculated by taking the total value of P raised to the power of $\frac{6}{5}$. But it would be absolutely faulty to take more than two significant figures for use.

Shape and Depth of Thread.—The form of the thread of screws is not determined mechanically by unvarying rules.

It is, however, necessary to take notice of this point also if it is intended that screws of different productions should be interchangeable.

In determining these forms it is necessary to bear in mind the conditions of manufacture, whether screws would be made by a screw-plate, which partially compresses, or better by means of the screw-cutting lathe or by cutting dies. Certain forms of thread are badly suited for the screw-plate, while other forms are made easily and well; the bottom of the groove should be easily impressed and the top of the ridge closed exactly.

The strength of the threads of the screw and of those of the nut must also be borne in mind. The force tending to tear out the screw is met by the resistance of the threads to being deformed or breaking. When the nut and the screw are adapted perfectly one to the other, the pressure is distributed equally amongst all the threads, and the strength is proportionate to the thickness of the nut.

For a given thickness of nut the strength will be the greatest possible when the threads of the screw offer the same resistance as those of the nut, from which it follows that if the nut and the screw are made of different materials of intrinsically unequal strength, the thickness of the threads of the screw and of the nut should be about in inverse ratio to the strength peculiar to the materials which compose them. It is on this account that in screws for wood the space between the threads is equal to several times the thickness of the metallic thread.

But it is useless for the total strength of the threads to be greater than that of the core of the screw. From this it follows that the proportion of the hollow to the ridge which gives the greatest strength is no longer imperative from the moment that the nut is of sufficient thickness, which is not necessarily great, and is almost always exceeded in practice. It is for this reason that mechanicians allow the same form of thread for screws intended to fix in wrought-iron, steel, brass, and cast-iron. The simplification which results from this does not generally offer any practical inconvenience, and can be admitted equally well for screws for horological work. In

large screws generally the same amount is left in the ridge as is removed from the groove. It has been preferred for the small screws to slightly increase the space, because in the generality of cases the metal of which the screw is made is stronger than that of the nut.

The form of thread which affords the maximum of resistance against rupture, in retaining contact between the screw and the nut, approaches the triangle with the base and the top of the thread rounded off.

Regarding the depth of the threads, if it is too great they would be lacking in strength, on account of the length of the accidental lever which tends to break them, and further they would be difficult to make. On the other hand, shallow threads give rise, by the reaction of the screw on the nut, to a wedging

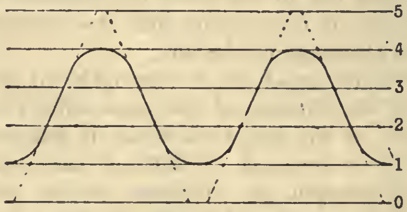

FIG. 27. DIAGRAM OF SWISS THREAD.

action, which tends to deform the threads faster in proportion as the screw is less perfect. The figure for the depth has been selected which best accords with the collective results of the best practice.

The following are the forms of threads adopted in the Swiss system:

(*a*) For screws made by the screw-plate, and intended for use in steel, in wrought-iron, or in brass:

1st. The depth of the thread is $\frac{3}{5}$ the length of pitch.

2nd. The top of the ridge is formed by a circular arc, the radius of which equals $\frac{1}{6}$ of the pitch.

3rd. The space between two consecutive ridges is formed, at the side next the core, by a circular arc, the radius of which equals $\frac{1}{5}$ of the pitch.

4th. To complete the generating figure of the thread, the two circular arcs, exterior and interior, are joined by straight lines tangental to the arcs, and which consequently form between them an angle of about 47½deg. The space between two ridges is therefore a little greater than the solid ridge.

5th. The positive generating figure of the thread should be considered as being the result of the figure above defined, slightly modified by the work of compression which occurs in threading with a screw-plate. It is thus that the circular arcs are changed into parabolic curves more suitable than the circular arc itself.

(*b*) For screws made by means of the lathe, and intended for use indifferently in steel, in wrought-iron, in brass, and in cast-iron the outline of M. Steinlen, of Mulhouse, is recom-

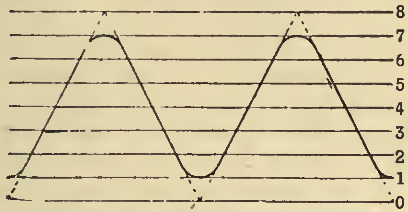

FIG. 28. DIAGRAM OF STEINLEN THREAD.

mended. The generating figure is an isosceles triangle, of which the base and the height are equal to the pitch. The height being divided into eight parts, one part is cut off the top of the thread, another part is added to the core between the threads. Further, the sides of the thread are joined one to the other by circular arcs both at the bottom and at the top. The actual depth of the thread is then three-quarters of the pitch, the sides forming between them an angle of 53deg. 8min., and the radius of the connecting arcs being ·1011 of the pitch.

The form of thread allowed for the compressing screw-plate may be equally well realised by the aid of dies. For this reason it is proposed to keep to this form invariably for all the screws in the diminishing series—that is to say, from 6 millimètres diameter and 1 millimètre pitch to the smallest

E 2

screws. The Steinlen thread would be allowed for all the screws in the increasing series, from 6 millimètres diameter *inclusive.*

Screw-plates which act by compression are worn by use, and the thread becomes less and less deep. It will therefore be necessary to slightly increase the depth of the thread in new screw-plates, and to guard against the employment of screw-plates considerably worn.

CHAPTER V.

BRITISH ASSOCIATION SCREWS.

THE British Association in 1881 appointed a committee to go thoroughly into the question of screw-threads of small diameters, and to report upon the same, which the committee did.

Report of the committee, consisting of Sir Joseph Whitworth, Dr. Siemens, Sir F. J. Bramwell, Mr. A. Stroh, Mr. Beck, Mr. W. H. Preece, Mr. E. Crompton, Mr. E. Rigg, Mr. A. Le Neve Foster, Mr. Latimer Clark, Mr. Buckney, and Mr. H. Trueman Wood (Secretary), appointed for the purpose of determining a gauge for the manufacture of the various small screws used in telegraphic and electrical apparatus, in clockwork, and for other analogous purposes:

"1. This committee was formed by the General Committee of the British Association assembled at York in August and September, 1881, for the purpose of determining a gauge for the manufacture of the various small screws used in telegraphic and electrical apparatus, in clockwork, and for other analogous purposes.

"2. At that meeting a paper was read by Mr. Preece, pointing out the desirability of establishing such a gauge. Although the Whitworth gauge is almost invariably adopted for the bolts and screws used in millwork and engineering in England, no general system has been hitherto applied to the smaller screws, used either in clockwork, philosophical instrument work, or in the numerous practical applications of electricity that are now rapidly becoming so important. In fact, at the

present time, gauges and screw-plates almost equal in number the makers engaged in the trade. One instance was brought to the attention of the committee, by a manufacturer who had to execute an order for railway signal apparatus, in accordance with three sample instruments, containing among them twenty-one screws of different threads, not one of which happened to be in use in his shop. There is now no recognised form of thread, no specified number of threads per inch—in fact, no generally accepted gauge, based on practice and experience. Great inconvenience is felt in providing for repairs, which are, in consequence, more costly and less efficient.

"The employment of some coherent and uniform system is manifestly required. It not only would render repairs easier, speedier, and cheaper, but it would introduce interchangeability of parts, and further the extension of piece-work; and it would reduce the equipment of workshops with special and costly tools.

"3. The subject of uniformity in screws has been very warmly taken up by the Société des Arts de Genève, which appointed a committee in December, 1876, who, after assiduous labours, issued a report in 1878. The system proposed by them has been very fully described by Professor Thury in two pamphlets published in Geneva.* The committee collected numerous screws of all sizes from many factories, measured them carefully, tabulated their several dimensions, and plotted the results by the ordinary method of linear co-ordinates. They determined the mathematical equations to curves that most closely corresponded with the ratios of diameter to pitch thus found to have been employed in practice, and adopted the one which most nearly represented the mean average proportions of the screws in use at various shops, and in different countries.

"The Swiss Committee took 1 millimètre pitch as the basis of their system. It was agreed that such a pitch was best adapted to a screw having a diameter of 6 millimètres. The form of thread adopted was triangular, the angle made

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* See Chap. IV.

by producing the two sides being approximately $47\frac{1}{2}$deg.; the depth being $\frac{3}{5}$ of the pitch, the top being rounded off by a radius $\frac{1}{6}$, and the bottom by a radius $\frac{1}{5}$ of the pitch.

"The committee has had an opportunity of examining screw-plates, and numerous packets of the corresponding screws manufactured on this system.

"The table on page 56 gives the pitches and diameters, in millimètres and 'mils,'* to two significant figures, and the number of threads per inch of all the screws comprised in the small screw series, which happens to cover the exact ground to which the attention of the committee has been specially directed, namely diameters below the $\frac{1}{4}$ inch.

"It is to be observed that the numbers by which the screws are designated, given in the first column, are not arbitrary. Each pitch of the series is $\frac{9}{10}$ths of that which succeeds it in the table.

"Thus the several pitches are:

$$1\text{mm.};\ \tfrac{9}{10}\text{mm.};\ \tfrac{9}{10})^{2}_{\text{mm.}};\ \tfrac{9}{10})^{3}_{\text{mm.}};\ \ldots\ \tfrac{9}{10})^{n}_{\text{mm.}}$$

"This series may be expressed in the form:

$$0{\cdot}9^{0};\ 0{\cdot}9^{1};\ 0{\cdot}9^{2};\ 0{\cdot}9^{3};\ \ldots\ 0{\cdot}9^{n};\ \ldots \quad (1)$$

whence it is at once evident that the designating number of the screw is the index of the power to which 0·9 must be raised in order to ascertain its exact pitch in millimètres.

"The method by which the relation between pitch and diameter is arrived at will be gathered from the following explanation:

"Let D represent the diameter, and P the pitch. Then, generally,

$$D = f\,(P)$$

"Evidently there can be no constant term, for when $D = O$ P must also $= O$. Moreover, D practically cannot be a simple multiple of P, for experience has shown that small screws

* The "mil" is a thousandth part of a British inch.

must have a less number of threads per diameter than large screws.

"TABLE OF SWISS SCREWS.

No.	Pitch.		Diameter.		Threads per inch.
	Mm.	Mil.	Mm.	Mil.	
25	0·072	2·8	0·25	10	357
24	0·080	3·1	0·29	11	323
23	0·089	3·0	0·33	13	286
22	0·098	3·9	0·37	15	256
21	0·11	4·3	0·42	17	233
20	0·12	4·8	0·48	19	208
19	0·14	5·3	0·54	21	189
18	0·15	5·9	0·62	24	170
17	0·17	6·6	0·70	28	152
16	0·19	7·3	0·79	31	137
15	0·21	8·1	0·90	35	124
14	0·23	9·0	1·00	40	111
13	0·25	10·0	1·2	46	100
12	0·28	11·	1·3	52	91
11	0·31	12·	1·5	59	83
10	0·35	14·	1·7	67	71·4
9	0·39	15·	1·9	76	66·7
8	0·43	17·	2·2	86	58·8
7	0·48	19·	2·5	97	52·6
6	0·53	21·	2·8	111	47·6
5	0·59	23·	3·2	126	43·5
4	0·66	26·	3·6	142	38·5
3	0·73	29·	4·1	162	34·5
2	0·81	32·	4·7	183	31·2
1	0·90	35·	5·4	208	28·6
0	1·00	39·	6·0	236	25·6

"Hence the formula will be of the form

$$D = m\,P^k \quad . \quad . \quad . \quad (2)$$

where m and k are constants to be determined.

"Since 1^k is 1 whatever be the value of k, it follows that the co-efficient m represents the value of D when P is 1. The Swiss Committee agreed that the unit pitch (1 millimètre) should be adopted for the screw having a diameter of 6 millimètres; in other words, they make $m = 6$.

"The value of k must be ascertained by trial.

"$k = 1$ would give a constant ratio, which we know is inadmissible.

"$k = 2$ will be found on trial to give a far too rapid decrease in the ratio of diameter to pitch.

"The several simple fractions between these limiting values were tried in succession, and the results obtained when using $\frac{6}{5}$ were found to give results that best accord with practice and experience.

"Substituting the values thus arrived at in (2), the formula becomes

$$D = 6P^{\frac{6}{5}} \quad . \quad . \quad . \quad . \quad (3)$$

"The Swiss system is thus very complete, but there are reasons which prevent this committee from recommending its adoption in its entirety.

"4. No one has done more to establish gauges of all kinds in England than Sir Joseph Whitworth. His classical paper on "A Uniform System of Screw-Threads"* was communicated as far back as 1841, to the Institution of Civil Engineers. He had made an extensive collection of screw-bolts from the principal workshops throughout England, and the average thread was carefully measured for different diameters. The ¼in., ½in., 1in., and 1½in. were selected and taken as the fixed points of a scale by which the intermediate sizes were regulated. The result is an admirable thread for the large iron bolts and screws used in fitting up steam-engines and other machinery. The angle made by the sides of this thread is 55deg. One-sixth of the depth of the thread is rounded off from the top, and one-sixth from the bottom. The actual depth is rather more than three-fifths, and less than two-thirds of the pitch.

"The slow adoption of such an admirable system was perhaps

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* See Chap. II.

due, in great measure, to the fact that it was put forward by an individual, and not by an association. A single individual, however exalted his reputation, cannot secure that immediate and universal attention which is obtained by such an organisation as the British Association. The system of units of electrical measurements sanctioned by the Association obtained instant recognition, and has now, thanks to the Congress of Electricians, held in Paris in October, 1881, become universally accepted. It is hoped that the same result will follow the recommendations of this committee.

"5. The question of the introduction of the metrical system occupied the serious consideration of the committee, but, considering the fact that it is not generally adopted in engineering or manufacture in England, and that it is as yet little understood by our workmen, it was thought better to suggest no change in this direction. The committee is not insensible to the simplicity of the metrical system and to its possible universality, nor to the fact of its gradual introduction in scientific circles, but while the manufacturing interests are still wedded to the British inch, and its multiples and sub-multiples, and while the British legal standard of length is still the yard, the committee has felt it impossible to suggest a change which has little chance of adoption, and which might jeopardise the introduction of that with which they are more concerned—viz., a uniform screw-thread.

"Hence it was determined that the unit of length taken should be the 'mil,' and that the decimal system should be adopted for expressing dimensions.

"6. The use of a screw is to draw together and to unite certain parts of apparatus in firm and intimate contact. To attain these ends, a screw must facilitate the application of mechanical power to draw the parts together, and it must possess strength to hold them so; it must not interfere with the easy separation of these united parts when necessary; it must possess durability—that is, it must be capable of repeated use without undue friction and without wear, otherwise it will speedily become loose and dangerous when frequently removed and restored. There has to be considered the pitch of the

screw, its relation to the diameter of the bolt on which it is cut, the depth of the cut, and the form of the thread. The pitch primarily determines the power of the screw, for it determines, for each diameter, the angle of the inclined plane; the depth determines the section of core left to resist shear or rupture; while the form of the thread determines the durability and efficiency, and determines also the surface of thread to bear endway strain.

"7. The committee have devoted very considerable attention to the pitch, form, and depth of screws, and they have compared together a large number of different kinds, some of which are in actual use, while others have only been suggested. They have, moreover, decided on recommending the adoption of the Whitworth form of thread, not only because it is so well known, but because experience has proved it excellent, and unsurpassed when employed for engineers' bolts. The committee, however, are not unanimous on all questions involved by this proposal, and as there are several points that require to be thoroughly sifted and tested, they ask to be re-constituted, and to be allowed a small grant to put their proposal to the test of practice, and to have a few gauges constructed for distribution or examination."

Second Report of the Committee, consisting of Sir Joseph Whitworth, Sir W. Thomson, Sir F. J. Bramwell, Mr. A. Stroh, Mr. Beck, Mr. W. H. Preece, Mr. E. Compton, Mr. E. Rigg (Secretary), Mr. A. Le Neve Foster, Mr. Latimer Clark, Mr. H. Trueman Wood, and Mr. Buckney, appointed for the purpose of determining a gauge for the manufacture of the various small screws used in telegraphic and electrical apparatus, in clockwork, and for other analogous purposes:

"1. Since the presentation of its first report on a gauge for small screws at the meeting of the British Association held in 1882, at Southampton, this committee has further examined into the recommendations there made, with the result that they have now to propose some important modifications, the general effect of which will, it is felt, be to materially facilitate the introduction of the system.

"2. The want of unanimity on the part of the committee,

referred to in paragraph 7 of that report, arose mainly on the question as to whether the inch or millimètre should be taken as a unit of measurement. It is evident that if either is rigidly adhered to, and in any way employed in the nomenclature of the screws, as for example, in specifying the diameter, pitch, or threads per inch or per mm., the same dimensions could not be expressed in whole numbers in the other unit, and thus a material obstacle would be at once introduced to its adoption.

"3. It should be pointed out, however, that it has hitherto been the common practice to designate such small screws as the committee alone is considering, not by any specific dimension, but by a number, which, as a rule, is arbitrarily chosen, and does not of itself form a guide to the size of the screw. Considering then, that the unit of measurement is only indirectly connected with the subject of a screw-gauge, the committee has felt that the two units might be reconciled so far as relates to such a subject, and that thus one important difficulty would be removed.

"4. The manner in which the series of screws adopted lately by Swiss manufacturers is correlated has been sufficiently explained in the previous report, and very full explanations are given in the two original pamphlets to which reference is there made.* The diameter (D) is related to the pitch (P) by the formula $D = 6P^{\frac{6}{5}}$, (1) all measurements being in millimètres, and P having successively the values 1 (or $0{\cdot}9^0$) mm.; $0{\cdot}9^1$ mm.; $0{\cdot}9^2$ mm.; $0{\cdot}9^3$ mm. . . . . $0{\cdot}9^n$ mm. Thus n, the index, becomes a convenient designating number for the screw, and the formula (1) may be expressed $D = 6\,(0{\cdot}9^n)^{\frac{6}{5}}$, where $P = 0{\cdot}9^n$.

"5. The pitch of any screw can be at once ascertained from its designating number by raising 0·9 to the power indicated by that number; and from this pitch the diameter is directly deducible by the formula (1), so that the number (n) given in the first column of the table, by which a screw is known, is intimately related to all its dimensions.

"6. It is evident that, by taking the exact successive powers

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* See Chap. IV.

of 0·9 for the pitch, complex numbers would soon be arrived at. Such dimensions would, however, involve a degree of accuracy which is hardly attainable in practice, and it may be shown that, with two significant figures employed throughout

"PROPOSED SMALL SCREW GAUGE.

No.	Nominal Dimensions in Thousands of an Inch.			Absolute Dimensions in Millimètres.	
	Diameter.	Pitch.	Threads per inch.	Diameter.	Pitch.
I.	II.	III.	IV.	V.	VI.
25	10	2·8	353	0·25	0·072
24	11	3·1	317	0·29	0·080
23	13	3·5	285	0·33	0·089
22	15	3·9	259	0·37	0·098
21	17	4·3	231	0·42	0·11
20	19	4·7	212	0·48	0·12
19	21	5·5	181	0·54	0·14
18	24	5·9	169	0·62	0·15
17	27	6·7	149	0·70	0·17
16	31	7·5	134	0·79	0·19
15	35	8·3	121	0·90	0·21
14	39	9·1	110	1·0	0·23
13	44	9·8	101	1·2	0·25
12	51	11·0	90·7	1·3	0·28
11	59	12·2	81·9	1·5	0·31
10	67	13·8	72·6	1·7	0·35
9	75	15·4	65·1	1·9	0·39
8	86	16·9	59·1	2·2	0·43
7	98	18·9	52·9	2·5	0·48
6	110	20·9	47·9	2·8	0·53
5	126	23·2	43·0	3·2	0·59
4	142	26·0	38·5	3·6	0·66
3	161	28·7	34·8	4·1	0·73
2	185	31·9	31·4	4·7	0·81
1	209	35·4	28·2	5·3	0·90
0	236	39·4	25·4	6·0	1·00

to express the pitch, the degree of accuracy likely to be attained in screws of the kind under consideration is reached. Relying on this fact, the series of pitches given in column VI. is arrived at for screws ranging from ·236in. to the smallest in use, 0·01in. in diametre, in place of the mathematically exact series obtained by raising 0·9 to successively higher powers. And this is the series which the committee recommends for adoption.

"7. Viewing the numbers thus obtained in the first place merely as a graduated series of pitches, and ignoring the unit of measurement, it may be admitted that the series of powers of 0·9 from which they are deduced is perhaps as good a one as can be suggested for the purpose, and it is found to very closely correspond with experience. Thus, column VI., which gives the nearest approximation to this series that is practically required, is well adapted for such a system of screws. It is to be observed that in selecting a series of pitches there are three simple alternatives to choose from—(1) To have a constant arithmetical difference between successive pitches, in which case either the pitches of small screws would differ by too great an amount, or those of the larger screws by too small an amount; or (2) to divide the entire range into sets, in each of which the differences are constant. The third alternative is to take successive powers of some other simple fraction, for example, 0·8, but such a series would not so well correspond with the screws most generally employed.

"8. Accepting this series, it may, however, be urged that it should be based on some aliquot part of an inch rather than on the millimètre. But any advantages to be gained by such a modification are inappreciable, for an examination of the numbers at once shows that they are, for the most part, awkward fractions of a millimètre, and the metric system of measurement thus enjoys no advantage in this respect over that based on the inch. From the point of view of interchangeability, however, of screws to be manufactured in this country and on the Continent, it is essential that the same basis of measurement of the pitch be everywhere adopted, because, having agreed upon only two significant figures on one basis,

terminable decimals are obtained, but such terminable decimals could not be accurately expressed by two significant figures on the other basis of measurement.

"9. Again, it is to be remembered that the use of metric measurement to designate the pitch need not inconvenience English manufacturers who are desirous of cutting the screws in their lathes. For, as has recently been pointed out by Mr. Bosanquet, it is easy to cut a thread, whose pitch differs from one millimètre by an amount which may for all ordinary purposes be neglected ($\frac{1}{55300}$th), with a guide-screw based on the inch by the addition of a wheel of 127 teeth, and thus the series here recommended could, on the rare occasions that it became necessary be originated on any screw-cutting lathe provided with the requisite wheels. But the committee do not consider it needful to specially contemplate facility in the originating of the threads, as the screws under consideration are made in a plate or by the aid of dies, and manufacturers on a large scale would be provided with a special lathe for the purpose.

"10. Whether the inch or millimètre is adopted as a unit of measurement, the series of pitches for these small screws becomes an ideal rarely attained in practice, for with screws tapped in a plate, or even with dies, the exact pitch aimed at will often not be attained; neither is it safe to assume that two screws, tapped in corresponding holes in different plates, will have precisely the same number of threads per inch. This is especially the case with the smaller screws, as may be proved by accurately measuring the pitches of several tapped in holes that are nominally alike.

"11. The fact here stated affords a reason against extending the practice of designating screws by their number of threads per inch, already sometimes resorted to in the case of large screws, to the screws now under discussion. It is found that screws, nominally alike, frequently differ in this respect by as much as five or even ten threads in the inch, nor need this occasion surprise when it is remembered that the screw-plates employed must expand to varying extents in the hardening, that the hole is often not more than three

or four threads deep, and that the pressure applied by hand must vary considerably. Such a nomenclature would thus involve the use of inconveniently high numbers to express a minute degree of accuracy but seldom attained, while they convey but little real information, since mere examination would not enable anyone to distinguish between, say, a screw of 169 and 181 threads per inch.

"12. The series of diameters must next be considered. Before the formula $D = 6P^{\frac{6}{5}}$ was adopted, it was ascertained by the minute examination of about 140 small screws that the series very closely corresponds with those recognised as good in the trade, and the screws made in the new plates, known as *Filières Suisses*, which the committee have had an opportunity of examining, appear to them to be well proportioned in this respect. The series of diameters, like the pitches, are expressed by two significant figures in each case, as the values for D deduced from the formula (1) are necessarily indeterminate in most cases. These diameters are given in millimètres in column V., and their nearest equivalent in thousandths of an inch in column II. As the committee considers that these screws are well-proportioned as regards pitch and diameter, and approves the formula (1) being taken as a basis, it is led to recommend this series of diameters being adopted in conjunction with the pitches already discussed. It has been suggested to the committee that the introduction of such a system into general use in this country might be facilitated by punching against each hole in the screw-plate, side by side with the designating number, as given in column I., the approximate diameter of the screw made in it as expressed in thousandths of an inch (column II.), as these numbers would convey a meaning to English workmen more definite than the numbers in column I. or column V. The committee sees no serious objection to such a course; but it should be remembered that screws have hitherto always been recognised by a number seldom higher than twenty-five, and it may be questioned whether any substantial advantage is gained by substituting such high figures as are involved in the expression of the diameters.

"13. It will be seen that the series here recommended gives twenty-six screws for the range from ¼in. to the smallest in use. Comparing this number with those of two of the best systems commonly met with—namely, the Latard (Perrelet et Martin) and Bourgeaux plates, we find that:

For a range of 21 sizes of watch screws on the Latard plate, this gives 15

For a range of 23 sizes of watch screws on the Bourgeaux plate, this gives 17

For a range of 36 sizes of clock screws on the Latard plate, this gives 23

The entire series is thus less than that of well-established plates, and cannot, therefore, be considered greater than the requirements of practice demand; while the fact that the watchmakers (who probably require the most extensive assortment of screws) in Switzerland have accepted it, confirms the committee in its opinion that the series is not deficient in this respect.

"14. It remains to consider the form of thread. There are so many practical points to be taken into consideration in discussing such a question that it becomes specially useless to rely much on theory for guidance; and the divergence observable among the forms adopted by different manufacturers is thus very great.

"The most important points to be borne in mind in its selection are:

"(1) The threads must be easily cut with the class of screw-cutting tackle ordinarily met with in workshops.

"(2) The strength of the threads on the male and female screws must be so correlated that the liability of either to strip is a minimum.

"(3) The resistance of the core to torsional stress when force is applied in rotating the screw must be a maximum.

"(4) The friction should be as small as possible, in order to reduce wear.

"15. In regard to the first of the above conditions, it is to be observed that very many of the screws considered by the committee are usually made by means of a plate in which are round tapped holes. Such a hole forms a thread by causing the metal to 'flow' from a space towards a thread, and its action is obviously of quite a different character from the cutting action of dies or of a chasing tool. In the case of plates with notched holes, the cutting and squeezing actions are combined.

"16. As bearing on the second condition, it is evident that, as the strength of the threads depends so essentially on the materials of which the screw and nut are made, and these are very varied, no precise and invariable rule is obtainable. If strength were the only point to be considered, a purely triangular form without any rounding would be the best, contact being assumed to take place over the entire surface. But in practice it is impossible to secure such perfect contact, and it becomes needful to round off the crests from all the threads; and this rounding is all the more necessary as the screws are smaller, and irregularities in the manufacture become relatively more marked. This modification is also necessary in view of condition (1) already considered.

"17. The third point—namely, the resistance of the core to torsional stress—is determined primarily by the depth of thread. If the sectional area of the ring cut away is less than that of the core, the probability of the latter breaking across may be regarded as approximately equal to that of the threads stripping; but it is impossible to maintain a constant ratio, as such a condition would require the thread to be so fine, in the case of small screws, that there would be no sufficient hold in the nut. Thus in the very smallest screws (those that are below ·030in. in diameter) the ratio $\frac{\text{area of core}}{\text{sectional area of thread}}$ is less than 1, and it gradually increases till a proportion of between 2 and 3 is attained.

"18. Condition (4) is evidently best satisfied by a square

thread. Such a form is, however, impracticable in the case of the small screws under consideration, but it is obviously approximated to according as the angle of a triangular thread is made less and the rounding greater.

"19. The angles that have been adopted in practice show, as might be expected, considerable variation. On the one hand an angle of 60deg. is rarely exceeded, the thread being thus derived from the equilateral triangle, and, on the other hand, 45deg. may be taken as the lower limit

"20. The depth of a thread is evidently a function both of its angle and of the amount of rounding at the top and bottom. It may conveniently be expressed as a fraction of the pitch (taken as unity). In the case of the small screws in general use the mean value of the depth thus expressed is found to be 0·563, the maximum being 0·771, and the mimimum 0·311. It is evident that any increase in the depth beyond what is essential will materially and needlessly increase the difficulty of manufacture when a screw-plate is used; at the same time the depth must not be too much reduced, on account of the greater tendency of the thread to strip. It is further important that the additional torsion involved in cutting a deep thread, which materially increases the risk of tearing the metal across, should not be lost sight of.

"21. The committee, after comparing together a large number of different forms of thread, some of which are in actual use, while others have only been suggested, were much tempted to recommend the Whitworth thread for adoption by the British Association, because it is so well known in this country, and experience has proved indisputably that it is excellent when employed for engineers' bolts, &c. But, as appears from sections 16 and 18, in the case of small screws the tendency should rather be to increase the rounding on account of the difficulties of manufacture, and the depth of the Whitworth thread is 0·64 of the pitch, which is considerably in excess of 0·563, the average adopted in practice. The Whitworth thread is, moreover, characterised by a greater angle than is usual in small screws.

"22. The advisability of modifying the form of thread of small

screws, as compared with those of greater diameter, is fully recognised by the Swiss Committee, their thread for the former having an angle of $47\frac{1}{2}$deg., while that for the latter is 53deg., nearly the same as that of the Whitworth thread. In the case of small screws made in the *Filière Suisse* the crest of each thread is rounded off with a radius equal to $\frac{1}{6}$th the pitch, and the hollow with $\frac{1}{5}$th the pitch. The actual depth is 0·60 the pitch, somewhat less than in the Whitworth thread.

"23. While approving the general form of thread here described, this committee could not but feel that the difference in the roundings ($\frac{1}{6}$th at top and $\frac{1}{5}$th at the bottom) was unnecessary. Looking, moreover, to the fact that very many of the screws of the sizes now under consideration are for electrical and telegraphic instruments, and, therefore, may be of brass, and that, with such dimensions, it is impossible for the eye to ascertain whether a given screw satisfies the required conditions in regard to such small differences between the crest and hollow of the thread, the committee feels that an equal rounding ($\frac{2}{11}$ths of the pitch) at the top and bottom would be preferable. This would maintain the angle of thread and the depth the same—namely, $47\frac{1}{2}$deg. and $\frac{3}{5}$ths of the pitch respectively.

"24. Having now discussed the three main points that require to be considered in any system of screws—namely, the pitches, diameters, and form of thread, it seems desirable to enumerate briefly the recommendations at which the committee has arrived. These are:

"(1) That the series of diameters for screws from $\frac{1}{100}$in. to $\frac{1}{4}$in. be that given in millimètres in column V., the nearest thousandths of an inch being given in column II.; these diameters being the series calculated by making P, in the formula $D = 6P^{\frac{6}{5}}$, having in succession the following values:

$$1 \text{ (or } 0{\cdot}9^0 \text{ mm.; } 0{\cdot}9^1 \text{ mm.; } 0{\cdot}9^2 \text{ mm.; } 0{\cdot}9^3 \text{ mm.; } \ldots\ldots \; 0{\cdot}9^n \text{ mm.}$$

Only two significant figures are taken to represent the diameters.

"(2) That the pitches of these screws be the above gradually

decreasing series, each pitch being $\frac{9}{10}$ths of its predecessor, but that only two significant figures be used in their expression. The series thus obtained is given in column VI.

"(3) That in view of the desirability of securing a system of small screws—international in its character—English manufacturers of screws, screw-plates, &c., adopt the exact pitches given in millimètres in column VI., which, as we explained in par. 9, can, if required, be originated on an English lathe. Further, in view of the fact that small screws and screw-plates, while nominally alike, will not unfrequently differ considerably as regards their number of threads per inch, the practice of designating such screws by their number of threads per inch should not be adopted. For reference, however, the approximate number of threads per inch, as calculated from the pitch given in column VI., are given in column IV.

"(4) That the designating numbers given in column I., being the indices of the powers to which 0·9 is raised to obtain the pitch, be punched against each hole in the screw-plate, and that, if thought desirable, its diameter in thousandths of an inch (column II.) might be punched side by side with this number.

"25. In his *Systématique des vis Horlogères**, Prof. Thury has done for the small screws used by watch, clock, and scientific instrument makers what was done forty years ago by Sir J. Whitworth for the larger screws used by engineers; and like the admirable system introduced by the latter, the scheme here advocated is based on the data obtained by measuring the several dimensions of many screws accepted by practical men as being well-proportioned.

"26. The committee has had an opportunity of examining both screws and screw-plates (for the smaller screws) made on this system, which it is convinced will satisfy all the demands of practice. The committee, can, therefore, confidently recommend its adoption by the British Association, subject to the slight modification discussed in par. 23; and

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* See Chapter IV.

it feels that an important incidental advantage would be the support it would at once receive on the Continent, and the consequent increased rapidity with which it might be expected to come into general use; for it cannot be doubted that its recognition by so important a body as the British Association would have considerable influence in establishing the system abroad."

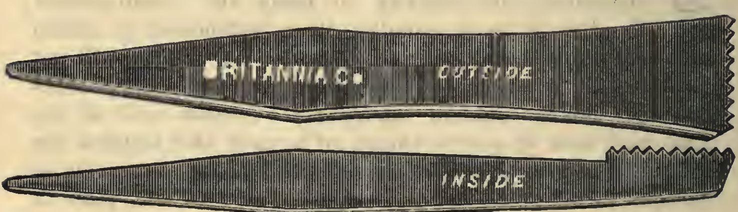
CHAPTER VI.

CHASING SCREWS BY HAND.

SUCCESS in this method of producing screws is altogether dependent on dexterity in using the comb-chasers Practice is more essential than instruction to attain proficiency in chasing screws by hand. An expert will set his T-rest at a convenient distance from the work, put his lathe in motion, and, on applying the chaser, will at the first start lead off a true thread of a pitch that matches the comb. The tyro will take an infinite amount of trouble to get his T-rest quite flat and smooth, and he will place it carefully parallel with the work on the lathe; then he will set his fly-wheel going and spend some minutes, perhaps, in getting a regular speed. At last he will apply the chaser; and what will be the result? May be no sign of a thread, but merely a series of grooves turned in the work; caused from not giving the tool a sliding motion, parallel with the axis of the work, whilst applying it. May be too much thread is the result, a double or triple thread is often made; it is caused by giving the tool too much sliding motion. May be a single thread of correct pitch is struck, and that the spiral is not regular in its pitch, but has a sharp crook in one part of its circumference to make up for the almost absence of inclination elsewhere. This thread is called "drunken," and is the great trouble with all beginners at screw-chasing. It results from the want of uniformity of sliding motion of the tool, or from irregularity in the speed of the work. The material itself often has a defect

which causes drunkenness in the thread; a piece of rod iron, having a seam along it, is almost sure to degenerate into a drunken screw, even though the thread may have been led off truly.

Contrivances of various kinds more or less ingenious, and in some cases quite impracticable, are continually being devised or revived, having for their object the fair leading of threads to be chased. It is safe to say that no contrivance yet devised, or at any rate made public, is practically free from objections that prevent its general adoption. Some aids to screw-chasing, after having been advertised for years, are no longer offered. It seems that nothing that has been proposed will supersede the manual dexterity to be acquired



FIGS. 29 AND 30. OUTSIDE AND INSIDE COMB-CHASERS.

by practice. The general principles of screw-chasing are therefore interesting.

Comb-chasers, for use by hand, are made in pairs: one for outside threads, the other for inside threads. They are called respectively male and female, and the accompanying illustrations (Figs 29 and 30) show the usual shapes. Their teeth form exact counterparts of the screw-thread to be cut, and differ in number and in size according to the fineness or coarseness of the rate they are intended to cut. These comb-chasers have their teeth cut by means of hobs, which are themselves duplicates of the screws, but usually very much larger in diameter, these hobs ranging from about 1in. to 3in. in diameter. They are frequently made in the form of a tube, and are then used on an arbor; this method is

both economical and produces a truer hob. The female chasers are cut on these hobs commonly by holding the blank chasers upside down on the T-rest; the shank of the chaser being crooked to avoid the poppet head-stock, and afterwards straightened. Female chasers made so, have the teeth slanting in the wrong direction for cutting nuts to fit right-handed bolts; the teeth are inclined correctly for chasing left-handed threads, which are but very seldom required. Comb-chasers generally sold at the tool shops are cut on right-handed hobs, and consequently the inside tools have the teeth slanting the wrong way, as just explained, the outside tools have their teeth slanting as they should be.

As a remedy, a compromise is occasionally resorted to by making hobs with series of rings, instead of a spiral, cut to the counterpart shape of the chasers required. These ring hobs will produce chasers with upright teeth, both for male and female tool, and these are better adapted for the purpose than when the pair are made on a right-handed hob. A prejudice exists against ring hobs and chasers produced by them; but such aversion is groundless, provided the ring hobs are equally well formed as the spiral hobs. A defect in one ring will not misshape the comb-chaser it cuts any more than a similar defect in one thread of the spiral hob, though a defect in each will produce opposite results. It is obvious that comb-chasers cut on ring hobs should be applied at several positions as the finishing is approached, so that a defect in the form of one ring, either ridge or hollow, communicated to the corresponding hollow or tooth of the chaser, would be obliterated by changing the relative positions of the tool and the work by moving the chaser lengthways of the hob one or more teeth. Similarly a defect in one part of the spiral hob may be communicated to every tooth in the chaser cut by it.

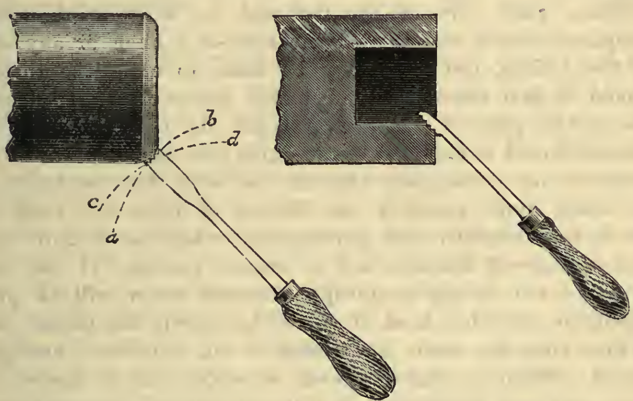
Hand-chasers are used chiefly by brass workers; screws on optical instruments are chased by hand, so are those on brass cocks and similar work. Formerly chasing threads by hand was commonly practised, but the screw-cutting lathe now brought into general use has superseded hand-chasing, and

even in brass work a guide is now coming into general use. This consists of a sleeve put on the mandrel, having the desired thread rate cut upon it, and a sliding arm that may be made to travel by this screw-guide and arranged to control a comb-chaser. This simple attachment, often forming one of the adjuncts to a brass-workers lathe, allows the hand-chasers to be used as quickly as without its aid; whilst it gives the certainty of a true thread. In Chap. XII. a lathe of this kind is illustrated.

Coming now to chasing screws by hand, it is well to consider the precautions to be taken so that the beginner may commence his practice under the most favourable conditions. An outside thread is to be preferred for a first attempt, as it is easier to see the action of the comb-chaser upon the surface of a cylinder than inside a hole. Sound boxwood is a good material to make initial trials upon. It should be turned true, parallel and smooth on the surface, and the end should be turned true also. The corner where the surface and the end meet should be rounded off smoothly, and the work is then ready for chasing. The T to be used should be smooth on its top, so that the chaser may slide along it freely, and the under side of the chaser should also be smooth, and the under corners rounded somewhat, for the same object. Adjust the T for height so that when the comb-chaser is rested upon it and lies horizontal, the tops of the teeth are level with the lathe centres. If the distance of the lathe centres from the floor should not be suited to the stature of the turner about to use the chaser, then the height of the T may be more convenient if placed differently. Therefore when the comb-chaser is laid upon the T and the handle is grasped by the right hand at a convenient height, with the knuckles under, the top of the chaser should be in a line radiating from the lathe centres. It is easy to adjust the T-rest up or down to suit these conditions, and if the lathe is of a convenient height for the operator, they will be found to exist when the tool is horizontal as first mentioned. The sole of the hand-rest may now be adjusted so that the T is brought with its front edge from a quarter to half an inch

from the work, and then firmly fixed. Have the comb-chaser intended to be used within reach, and set the lathe in motion; get a regular speed by treading evenly, not very fast, nor yet very slow, regularity being the most essential thing to attend to.

Grasp the handle of the chaser in the right hand, knuckles below; put the fingers of the left hand round the socket of the T-rest, leaving the thumb free to hold the chaser, which is now laid on the top of the T. Let the teeth of the chaser be a short distance from the work, and hold the tool down



FIGS. 31 AND 32. USING COMB-CHASERS, MALE AND FEMALE.

with the thumb of the left hand; now move the right hand, still grasping the handle, towards the right, and the teeth of the chaser will move to the left. Thoroughly master the effect of this motion before allowing the teeth to touch the work. Simultaneously the lathe must be kept running at a regular speed, the tool must be held to the T by the left hand, and the right hand must move to the right and back again. This motion of the hand gives the handle of the chaser a circular movement, and a corresponding movement to the teeth; the centre on which the chaser oscillates being

the point at which it is held to the T by the left hand. Next acquire the knack of withdrawing the tool slightly at the end of each motion of the handle to the right, when doing this release the grip with the left thumb on the tool, and replace it after returning the handle to the left. Great expertness should be attained in handling the tool, as just described, before attempting to make it cut a thread. Fig. 31 shows this action that has just been described, the circular movement of the teeth being indicated by the dotted arc lines *ab* and *cd*. The internal chaser is shown in position at Fig. 32.

When quite sure of the tool and the work being under complete control, and there is no fear of a hitch in any one of the actions, the comb may be made to cut. The thread should be first traced on the rounded corner of the wood, and the middle part of the comb should do the cutting. The desired thread is obtained by swinging the handle of the tool round so far during one turn of the work that the teeth of the comb move precisely the distance of from one tooth to the next. Carefully and persistently endeavour to move the tool the correct distance, and so ensure success. If the tool is moved too quickly a multiple threaded screw will be produced; on the other hand, if moved too slowly the thread will be finer than the comb is intended to cut, and also a multiple thread. When a slight scratch is made, that is correct in pitch and not drunken, it is followed up and deepened with the comb-chaser which it now guides. Should a mistake be made in the first attempt, the imperfect thread should be entirely obliterated, and the corner of the work rounded off preparatory to a fresh trial at striking the required thread. It should be clearly understood that the rounded corner of the work is the only part that the screw tool is allowed to operate upon in getting the first trace of a true thread.

Having once traced, even though very slightly, a true thread on the corner, the comb-chaser is used to follow up and deepen it; this is proceeded with gently at first till a full thread is obtained on one part, and then the extension of the screw along the work is quite an easy matter. Always take

care to allow that part of the thread that is already cut to guide the comb when cutting farther.

It has been already mentioned that a comb screw-tool held stationary on the T-rest in contact with the rotating work would cut only a series of rings corresponding in form to the teeth of the chaser. But if, during the first rotation of the work, the tool is gradually moved the distance between two of its teeth, a true screw is formed. Any difference in the relative distance moved by the tool and distance between its teeth will cause an error in the truth of the screw, but if this error is not great a sufficiently good screw may be formed during the progress of cutting up the full thread as the operation may be conducted so as to correct the error.

A great error in the truth of the screw first struck may be beyond correction. For example, the *distance* moved by the tool may be correct, but if the motion be unequal the thread will be drunk. The tool may be moved too far, just sufficient to produce a double thread, or may be moved not far enough, just sufficient to produce a thread half the pitch of the teeth of the comb. These errors are usually beyond correction and when either of them is found to have occurred after the first trip of the comb, the slight scratch is obliterated by turning the work smooth and a fresh start is made. The collection of points on the ordinary comb screw-tools, as used on hard woods and metals, render the striking of screws comparatively easy if sufficient pains are taken to attain proficiency. Single-point tools used for screwing the soft woods do not, however, allow of manipulation in this way. They are used with some guiding appliance, a traversing mandrel being usual.

Some good notion of the traverse of a comb tool may be got by mounting a true screw between the lathe centres, taking a comb-chaser of the same pitch, setting the lathe in motion, and applying the tool to the thread, not allowing it to cut, but merely letting it travel along by the action of the screw. This experiment will demonstrate the rate of traverse of the comb-chaser with a given speed of the fly-wheel, and the knowledge so obtained may be usefully applied

when experimenting in trying to strike a thread of the same pitch.

An internal screw may be tried after success has been attained with the outside thread. For this make a large hole in a piece of sound boxwood, and round the corner as previously recommended. Use the female comb-chaser to strike a thread on the rounded corner and follow the practice which previous experience has taught to be the best. When a true thread is started on the rounded corner, follow it on into the hole, and gradually bring the comb-chaser round, so that its teeth lie parallel with the axis of the work, and thus get a thread cut that is of equal diameter from end to end. If a tap is used to trace a thread in a hole, and the trace is followed up with a comb tool, it is easy to observe the rate at which the tool advances and to adopt the same speed, as nearly as can be judged, when using the same comb tool to originate a thread, of the same pitch. See Fig. 32.

The practised hand will take a comb-chaser of any pitch, and will use it on a lathe of which he has had no previous experience as to speed, &c., and he will strike a true thread with unerring promptness. In his case practice has brought skill, and the like means will produce a like result in the least successful beginner at chasing screws by hand.

The traversing mandrel, as a means of mechanical guidance for cutting short screws, appears to have been known at the time when running mandrels were first used. The old books on turning show many illustrations of them. In this form of lathe headstock the mandrel is fitted in parallel bearings, and is free to slide longitudinally in the bearings when desired. When used for plain turning, the traversing motion is prevented by a cap placed on the tail-end of the mandrel, or by some similar arrangement.

Fig. 33 shows a lathe with traversing mandrel. It is manufactured by the Britannia Company, Colchester, and is priced at £22 10s.; 5in. centre, and bed 4ft. 6in. long. This lathe is constructed to the design of the Rev. J. Lukin, and is fitted with traversing mandrel and six guides for chasing screws on optical instruments, &c., and on box-lids and similar work in

wood. This type of lathe is the one best suited for ornamental turning, and a great variety of very beautiful ornamental work may be done on it with suitable appliances.

For cutting screws, the traversing mandrel is made free of all longitudinal confinement by removing the cap above referred

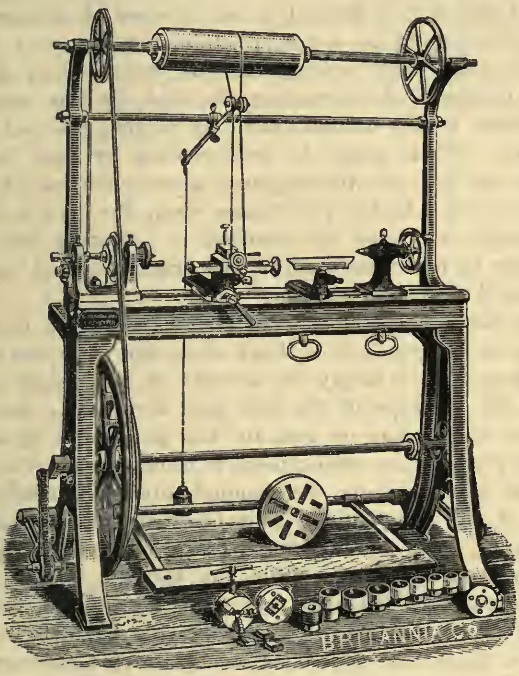


FIG. 33. THE LUKIN LATHE FOR ORNAMENTAL TURNING.

to. A guide-screw in the form of a steel ring takes its place, and on bringing some attachment of the lathe headstock to form a nut for the guide-screw on the mandrel, and on rotating this latter it will travel longitudinally at the same rate as the screw-thread cut upon the guide.

When cutting a screw by the aid of the traversing mandrel, the tool used is held firmly either by hand or by the slide-rest just as though a plain ring groove were to be turned. The lathe is set in motion by a partial rotation only of the fly-wheel, which is swung to and fro by the treadle. By this process a thread is cut not longer than the traverse of the mandrel, and if it is desired to cut a screw of greater length the tool is moved to a new position, but always a distance equal to some exact multiple of the thread being cut; the thread is carried farther along the work by this means and still farther to any desired extent by moving the tool to new positions. When using the comb-chasers by hand the teeth at once fall into the thread-groove already cut each time the tool is moved. In the rarer cases when the tool is fixed in a slide-rest, care must be exercised in adjusting its position accurately to follow the path of the original thread each time it is moved to a new position.

When the work to be screwed on the traversing mandrel is too long to be turned in a chuck alone, the outer end requires supporting, if not simply on account of its weight at least against the pressure of the tool used for chasing the thread The cone centre may be used for this purpose as in ordinary turning, provided an arrangement is made to allow the poppet barrel to slide back as the mandrel advances under the influence of the screw-guide. This is often done by making a special cone point with a parallel fitting and pressed up to its work by a spiral spring within the barrel. A plan that is more satisfactory, and that may often be adopted, is to use some round part of the work as a bearing by fitting a collar to it and supporting the collar in a plate or temporary head-stock. This supports the work against side thrust, whilst it does not impede its free traverse.

The traversing mandrel is a convenient guide for people who cannot chase screws on the ordinary plain lathe with comb-screw tools. The latter method is, however, so much preferable in several ways that the moderate amount of time and application necessary to succeed should be cheerfully afforded by anyone aiming to become an expert at the lathe.

The traversing mandrel needs but little preparatory change to make it available for screw-cutting. When set free of longitudinal restraint half-a-dozen varieties of guide-screws afford a sufficiently wide choice of thread-rates for most purposes when taps and dies are available. The thread-rate of any guide-screw may be copied on wood, metal, ivory, or other materials, on any diameter of work within the capacity of the lathe, and both internal and external. Comb-screw tools used in pairs thus furnish a ready means of screwing pieces, the diameters of which do not adapt them to the ordinary sizes or rates of taps, dies, &c.

CHAPTER VII.

SCREW-PLATES, DIES, AND TAPS.

SCREWS of small diameter are often made by the aid of screw-plates. These are to be bought commonly at the tool shops, or they may be easily made by any mechanic who can harden and temper steel. Screw-plates act more by pressure than by any semblance of cutting the thread; the screw-blank, on being screwed into the screw-plate, has the groove between the thread indented and the metal is caused to flow towards the ridge. The screws thus produced are often larger in diameter than the blank before threading, and they are always longer, and the severe strain tends to rupture the blank. It is easy to infer from these remarks that screw-making by screw-plates is not a highly satisfactory process from a mechanical point of view.

The screws so produced are generally only intended to fasten pieces together, and are all-sufficient for this purpose. Now automatic machinery is used much more economically and much more satisfactorily in making large quantities of screws which can be sold at a mere tithe of the cost. The small screws used in watch-work are produced entirely by perfectly automatic machinery, and illustrations of this are given in Chapter XII.

For some odd jobs, and particularly for finishing screw-threads to a uniform gauge, a screw-plate comes in handy. The method of making one is simple. Select a piece of flat cast-steel and drill a hole through it the tapping size of the thread; usually the dimensions of the steel for a single

hole are roughly about four diameters of the thread wide, and about the same thickness as the tapping size. Smooth off any burrs, and chamfer the hole on both sides; then screw the tap through it, taking care that it goes straight. The chamfering tool may now be again applied to remove the burr thrown up by the tap. If the hole were not chamfered before tapping, the chamfering tool would be led aside owing to the first turn of the thread having cut a path eccentric to the original hole. The effects of chamfering a hole before tapping, and of doing so after tapping, are not alike, and it should be recollected that to get a fair lead into a screwed hole always chamfer *before* tapping. If several holes are wanted in the screw-plate, mark them off and drill them, and chamfer all before tapping any; then tap all of them, rechamfer the holes, then harden and temper the steel, and the screw-plate is finished and ready for use.

In threading with the screw-plate the screw-blank should be prepared rather smaller in diameter than the full-sized thread, and it should be made somewhat pointed to enter the hole in the plate easily. Then with plenty of lubricant, oil for preference, the screw-blank can be screwed into the plate; the thread will be formed by squeezing the metal out of the groove, and by causing some of it to swell the ridge beyond the diameter of the screw-blank. To determine precisely the right size for the blank to cut a full thread, make a tapering blank and screw it into the hole till the full thread comes up, and then measure the diameter of the taper at that part.

The plain screw-plate already described is sometimes, and especially in the larger sizes, notched across the threads at two or three places about equi-distant round the circumference. These notches are made with a warding file, and often terminate in holes, which have been drilled for the purpose, just clear of the thread. The notches made thus are supposed to form cutting edges to the thread, and a screw-plate so treated it is supposed will cut the thread instead of squeezing it. Something more than merely notching the hole must be done to get the plate to cut, and it is

this: all the imperfect thread which forms the first turn in the screw-plate must be removed so that the first cutting edge of the leading thread is a *full* thread. The same precaution is taken with dies, and the effect is perhaps easier to see in these than in a screw-plate. A small sharp cold-chisel will usually be the best tool to use for cutting away the imperfect portions of the thread. A refinement in a screw-plate is to make the first two or three cutting edges in steps, so that they divide amongst them the work of cutting a full thread. The general construction of the screw-plate does not, however, merit such attention to detail unless the whole tool is made according to the principles of the solid dies next to be described, which are perfected screw-plates.

Solid dies are a development of the screw-plate, and they are now used quite extensively for cutting threads of all kinds, and machine-made screws are mostly made with them. Gas and water pipe is also threaded with solid dies, as one trip of the die produces a thread of accurate gauge. An ordinary form of solid die and stock for this purpose is shown by Fig. 34. A special form of die-stock is shown at Fig. 35. This is particularly useful when screwing work that is fixed in places that do not allow free access. In Fig. 35 the die fits in a receiver that is moved by pawls in either direction as wished. The one lever handle is used with a to-and-fro motion, and even only a few inches of motion suffices for screwing successfully. This form of ratchet die-stock is often used for gas and hydraulic piping that has been fixed, and to which alterations are required. The same appliance is used for actuating a tap when space does not admit the usual tap wrench. The screwing-die itself is a round disc of steel having a central hole through it tapped to size. Four smaller holes are drilled at equal distances round the tapped hole just clear of the thread, and then the intervening metal is removed, and the four right-hand edges are filed to cut, the left-hand edges being backed off to prevent breakage when unscrewing the dies. Thus far the method of making is simple. The next thing to do is to touch up the four

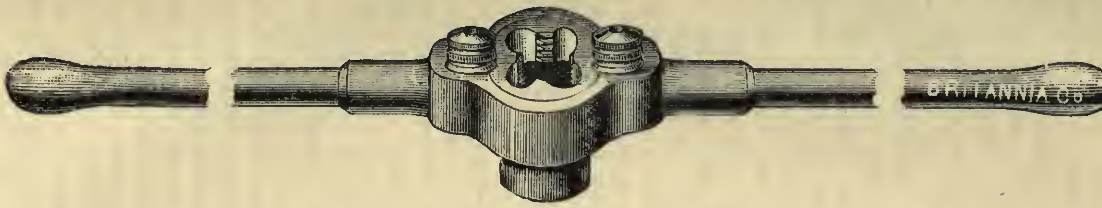


FIG. 34. SOLID DIE AND DOUBLE-HANDED DIE-STOCK.

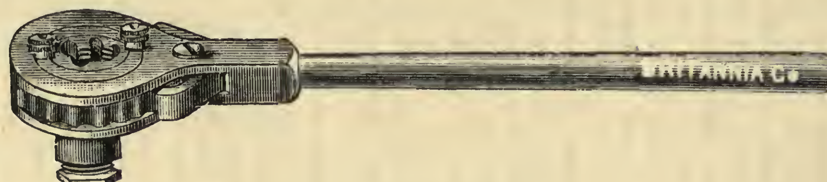


FIG. 35. RATCHET DIE-STOCK.

threaded portions with a file, using a crossing file, a half-round, or a rat-tail, and to clear away that portion of thread behind the cutting edge, so as to give an angle of relief. Also to file down the cutting edges at the four points of the first turn of the thread; doing this so as to make the four points a series of cutting edges, each following one cutting slightly deeper than the one which precedes it, thus dividing the work of cutting the full thread amongst the four cutting edges in equal proportions. Solid dies are made to cut from one side only, and do not cut when reversed. The holes round the edge are made large so that when the spaces are filed out they are as wide as, and they may be wider than, the threaded portion between. Thus, not more than half the circumference of the screwed part of each die is left. Such dies are commonly fitted to die-stocks, as shown in Fig. 34, when used by hand; they may be held in a chuck when used on the lathe, or they may be fitted into some similar contrivance when used on a screwing-machine, as shown by Fig. 80.

Dies that are made in this way really cut the thread, and they are now in general use as before-mentioned. The large holes round the side allow a good-sized file to be used when shaping the edges, and the dies can be quickly made. The same principle carried out in a screw-plate would produce an equally effective tool. The difficulty is chiefly when the smallness of the hole does not allow a file to be used freely.

In order to lead the work straight into the solid die, it is often fitted with a guide. This is a portion of the stock forming a projecting sleeve, bored out truly to the full diameter for which the stock is intended to be used. All smaller sizes are accommodated by fitting a tube into the sleeve, having its internal bore to fit the smaller size. The screwed part of the die must always be quite straight with the bore, and precautions must be taken to ensure this.

Screwing - dies most commonly used in general work are made in two parts, fitted to a die-stock in which they are free to slide for a small distance so that they may be brought closer together as the work of cutting the thread

proceeds. Illustrations of the usual forms of die-stocks for two-part dies are shown on page 89, and a pair of dies are illustrated at Fig. 36.

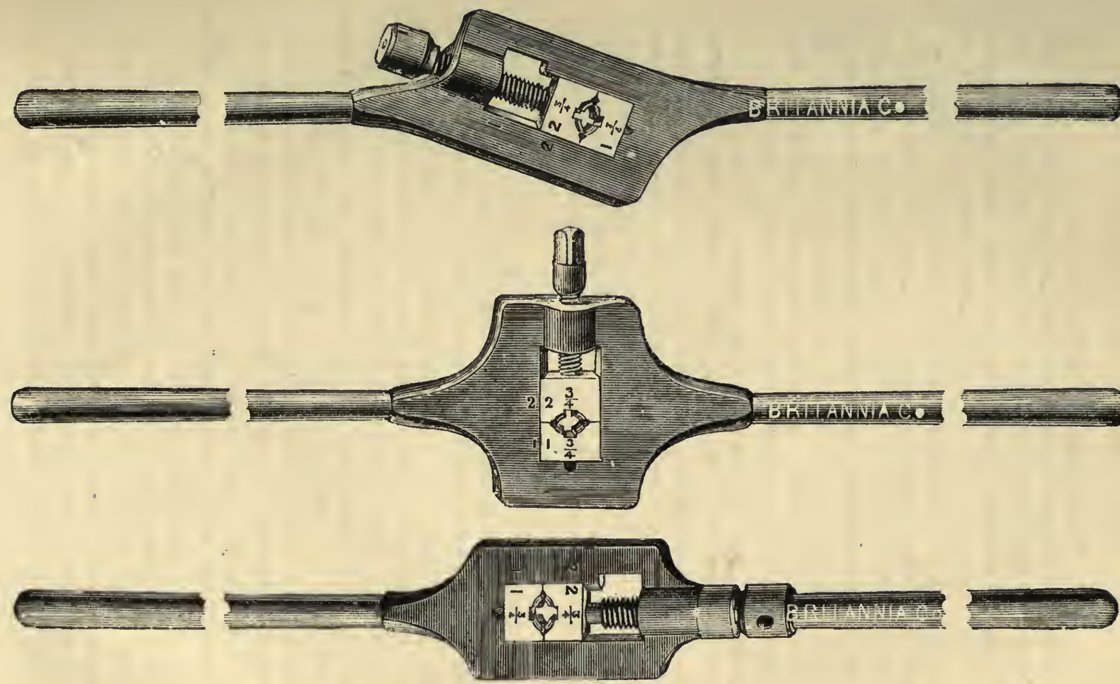
The slot in which the dies are fitted has angular slides, and the dies have a corresponding V-groove in their edges to fit these angles. About 60deg. is the usual angle adopted in practice; a triangular file then serves to form the groove in the die. The top of the angle formed on the die-stock is always flattened, and the bottom of the groove in the die is conveniently made rounding. This is a safer form for the steel when hardening, as sharp angles always are liable to lead a crack in the steel. The rounded bottom is easily made by drilling holes in the dies at the correct distance apart, and then filing the V-groove into these holes. This plan relieves the corner of the file, and makes the filing of a

FIG. 36. PAIR OF SCREWING DIES.

straight and well-fitting groove easier. When a pair of die-blanks are fitted so that the one beds on the bottom of the stock and the two meet closely, they are ready to be threaded.

Generally only two dies are used, the screwed surface of each one including from a third to nearly a half of the circumference of the screw. A notch is made in the central part of each screwed surface, so that a pair of dies present, on their screwed surfaces, four arcs and eight series of cutting points. When the curvature of the dies, and of the work they are operating upon, are alike, four of these series of cutting points operate when the dies are moved in one direction, and the other four when the dies are reversed.

As the two most essential points aimed at are operated in precisely opposite ways from a similar cause, much attention



FIGS. 37, 38, 39. VARIOUS FORMS OF DIE-STOCKS FOR TWO-PART DIES.

(Made by Britannia Company.)

has been given to investigating the shaping of dies. Dies that have smaller curved surfaces penetrate easier, cut quicker, and compress the screw less than dies with greater curved surfaces, but these lead more truly and maintain throughout the cutting a better thread form.

Obviously the effect of different diameters of die-arc and of work must be want of contact between them, and this must be in proportion to the difference. When the arc portions of the dies are most out of contact the guiding power is least, and false rates are likely to be cut. The dies will, under these conditions, sometimes cut a fine single thread one-half or one-quarter the true pitch of the dies, or perhaps a double or a triple thread of the same pitch as the dies, or may be merely concentric grooves will be cut by the dies. These results, which properly form curiosities in screw-cutting, are not rare; they are caused through the dies having been closed on the work obliquely, or from the dies not fitting the stock. The dies may be thus caused to cut a distinct thread with each series of teeth, instead of all these combining to form one thread only.

Dies, screw tools, and so forth, are made with master-taps, which are intended for reproducing screwing tackle, and are not to be used as working-taps. A better shape for action is made when the master-tap used is larger than the nominal diameter of the thread. Usually master-taps are made one depth of the thread larger than the size of the working-tap, but sometimes they are made two depths larger. The reason for this will be apparent on examining the action of a pair of dies when closed on a screw-blank preparatory to cutting a thread. It will be noticed that dies threaded with an ordinary working-tap touch the blank only at the outer corners of the threads, owing to the diameter of the circle forming the arc of the *bottom* of the thread, that is, the most prominent part of the thread in the die, being smaller by the amount of the thread's depth than the screw-blank on which the dies are closed. These corners of the dies do not lead well, partly from the small amount of thread in contact, but chiefly because the angle made

by the points of the threads is not the correct rake for the screw at the diameter of the blank. Obviously the rake of a thread is greater at the bottom of the groove than it is at the top of the ridge, because the pitch must be the same in both cases, and in the former the amount of rise is less (by double the depth of the thread) than it is in the latter, as explained on page 4.

The points of the dies in contact with the screw-blank are the parts corresponding to the bottom of the thread in the finished screw, and they are of corresponding rake. They, however, touch the top of the thread on the screw-blank, and consequently do not lead the correct rake. As the cutting of the thread proceeds, and the dies approach nearer to cutting the actual diameter of the screw, the rake of the thread in the dies and that of the screw being cut become nearer alike, and on the thread being completed the rake of dies' thread exactly corresponds with rake of screw cut by it. So much for the action of dies cut with an ordinary working-tap.

Dies cut with a master-tap, which is larger than the working-tap by two depths of the thread, when closed upon a screw-blank of nominal size will touch all round the threaded arcs of the circle. The most prominent points in the dies are, as in those last described, that part of the thread which will form the bottom of the groove. The tap used for threading the dies being the same diameter at the bottom of the thread as the outside diameter of the screw to be cut, it follows that the arcs of each are alike, and that the rake of the thread at the bottom of the groove in this large tap is exactly the same as the rake of the thread at the top of the ridge in the nominal size. The dies will therefore lead a thread of correct pitch on the screw-blank, and also will lead a true thread. As the cutting proceeds, and the dies are closed to smaller diameter, the arc in contact diminishes, and the lead of the dies is less accurate. Also the angle of the cutting edge becomes more acute as the dies close, and they have the disadvantage of cutting ranker at the finish than at any

other time of the work. This rankness of cut at the last is the most serious drawback; the lead of the dies is most effective when most wanted, that is, at starting the thread, but it would be better if the cut diminished as the work proceeded, and so afforded a nicer adjustment towards the finish.

With a view to combine the good and to suppress the bad points inherent to dies cut on taps of the working size on the one side, and on the other those cut on master-taps double the depth of thread larger, a medium course is commonly adopted. That is, a master-tap is used which is one depth of thread larger than the nominal diameter. Dies cut on such a tap are a compromise between the two kinds previously described. They lead better than the dies cut on a working-size tap, but not so well as those cut on a large master-tap, and they finish better than the latter, but not so well as the former. The medium size master-tap is preferable for two-part dies that are intended to cut the thread entirely from the blank; the large size master-tap for those intended to cut the bulk of the thread, which is then finished with a solid die or screw-plate; and the working-size tap for those intended to finish the thread to shape after the bulk has been removed with a point tool in the lathe.

Resuming now the making of the pair of dies, from which subject we digressed to consider the purpose of master-taps. The dies should be separated by pinching between them a piece of flat iron or brass, the thickness of which may be from about $\frac{1}{16}$in. to $\frac{1}{8}$in., according to the depth of the thread. Mark the centre between the two dies and drill a hole the tapping size of the thread. Tap this hole with the ordinary tap used for the thread, and then slack the dies and take out the packing between them.

The dies, after tapping with the working-tap, are next threaded on a master-tap, unless it is decided to have them from the working-tap. The dies are next filed up so as to cut; if made on a working-tap all the cutting will be on the outer corners, if made on a large master-tap all the cutting will be on the

notch at the bottom of the threaded half-circles; if made on a small master-tap the cutting will commence on the outer corners and finish on the notches. The small dies need no notches, and the large dies need no shaping on the corners, but the medium size dies require both in order to cut.

The cutting edge of each die should be made to the proper angle for the material it is intended to act upon. Whether on the surface corners or in the notches, the shape should be the same, and about 60deg. will give a good edge for general purposes. To take the measurement of the cutting angle, draw a tangent to the circle forming the thread, at the point of the cutting tooth, then make the face of the cutting part enclose 60deg. with the line forming the tangent. The cutting edge of a screwing die should be formed precisely like the cutting edge of a lathe tool, or any other cutting instrument. The front face of the tool, that is the one which should have 3deg. clearance from the work in all tools, is represented by the threaded portion of the die. A straight line drawn so as to touch the cutting point of the die, but not pass through a circle representing the thread, will give the front face of the tool, and from this line the angle of the cutting edge is to be measured. If when the working size the dies close completely, and they are divided exactly across the centre, as they would be in such a case, then the angle of the cutting edge at each corner of the dies would be 90deg. If the dies are filed away so as to leave a space between them, then the angle of the cutting edge would be greater still. From this it is apparent that the face of the die which meets the cutting edge must be made to rake back, and not to form a plane on a radius from the centre of the threaded hole.

A drunken thread is caused from the dies being improperly placed so that the thread cut by each does not exactly coincide. It therefore does not lead into itself evenly on the first turn of the dies, but does so by an abrupt alteration in the spiral curve, and this continues to the end. When the points in contact are narrow they allow this irregular curve to endure, and the die-stock is said to wabble on the work. When the surface contact of the dies is broad there is less chance

of this drunkenness occurring, and also more chance of its correction as the cutting proceeds.

Die-stocks of the shape shown at Fig. 40 are often fitted with three or four dies, and are then tapped with two or three different threads. Fig. 40 shows four dies tapped to cut three threads.

The defective action of two-part dies, as explained on a former page, has led to many attempts at some other form of construction that shall cut the thread in a better way. Whitworth's patent guide-stocks and dies, shown at Fig. 41, have overcome the objections; and the direct action, guide-stocks, and dies, shown at Fig. 42, are practically the same in action.

The three-part dies are so arranged that one die, the

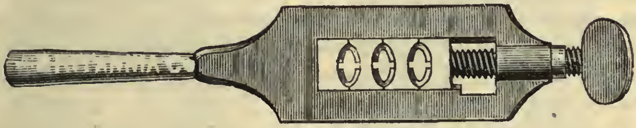


FIG. 40. DIE-STOCK WITH THREE DIFFERENT THREADS.

(Made by Britannia Company.)

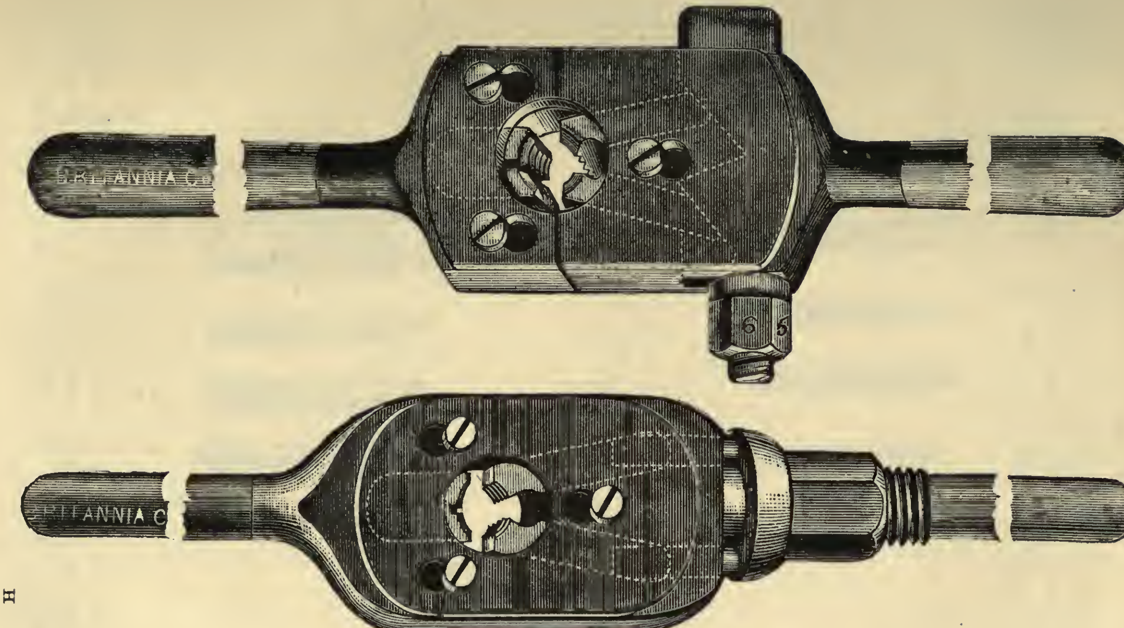
stationary one, serves only as a guide, and two dies, moving in grooves which are *not* made radial, do all the cutting, one in each direction. These cutting dies are so shaped that they can be sharpened on the grindstone from time to time, as the edges become dull. The thread is cut with a large master-tap so that the lead is perfect at the commencement of the thread. Though more trouble to make, and consequently more costly, these dies are in many respects so much better than the common form of two-part dies that their use is true economy.

For making screws in soft woods a screw-box is commonly employed. This consists of two pieces of wood, the thicker of which has its ends shaped into handles, the thinner piece is attached by screws, and is nicely adjusted by steady pins. A

hole is bored through the screw-box, the same diameter as that of the bottom of the screw to be cut. The two pieces are separated, and the hole in the thinner one is enlarged concentrically to the external diameter of the screw. The hole in the thicker piece is tapped to the gauge of the screw to be cut. The V-shaped cutter is a steel strip having its external edge shaped to suit the thread, and notched internally with a saw file to make a thin cutting edge. This cutter lies in a groove cut in the thicker piece, and is fastened by a wedge or a screw. The position of this cutter in respect of the threaded groove requires accurate adjustment and in several respects. The edges of the cutter formed by the V-notch should form an angle of about 100deg., with the side on which the apex of the V is, usually called the back of the cutter. The point of the V should exactly intersect the ridge of the thread tapped in the screw-box. The cutter should lie in the groove with its edge inclined precisely in a line with the angle of the thread, so that the lead or inclination is correct. Finally the apex of the V-point should form a tangent to the bottom of the thread being cut.

The wood to be screwed by this appliance is first turned truly cylindrical and somewhat pointed. It is then presented to the large hole of the box and screwed in. The cutter makes a V-notch, which allows the wooden worm in the box to pass and draws the work forward at the rate determined by the thread. The cutter removes the whole of the wood within the V at one trip along the work, the shaving escaping through the mouth which is formed by a channel cut in the thicker piece from the point of the cutter to the side of the box. This appliance is very effective in use, and has been employed for large screws up to 8in. diameter, but now iron screws have very generally superseded wooden ones.

This screw-box will cut a thread close up to a shoulder if, after being used in the way above described, it is taken off the work and the thinner piece is entirely removed, when the screw-box is again screwed on and the thread can be cut to the shoulder. For cutting the internal thread a special form of tap is used, as shown at Fig. 46.



Figs. 41, 42. Three-part Dies and Die-stocks.

Taps (see Figs. 43 and 44) are used to form internal threads. For general use three form a set, one an entry-tap, one a plug-tap, and one a bottoming-tap. The first is made tapering so that

FIG. 43. ENGINEERS' TAPS.

the small end is not larger than the bottom of the thread, and this tap will usually enter, a distance about equal to its diameter; a hole bored the proper size for tapping; the taper of the tap

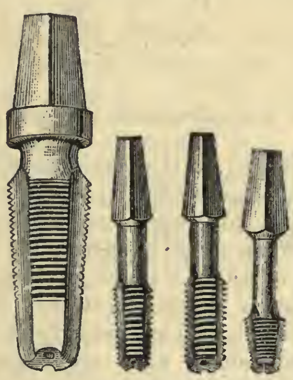


FIG. 44. GAS-FITTERS' TAPS.

graduates from end to end of the threaded part. If this tap were passed completely through a hole a full thread will be cut, but not if screwed only partially through. It will commence

and finish the thread in a nut or other hole where it may be passed right through. When the hole to be tapped is very deep, or when it has a bottom, and consequently the tap cannot be screwed through it, the taper-tap is followed by the plug-tap. This is made tapering only near the end; the first few turns of the thread being reduced so as to follow the taper-tap. The taper part of a plug-tap usually does not extend beyond a distance equal to about from three-quarters to one diameter of the thread. A hole that is from one and a-half to two diameters of the thread deep is screwed first with the taper-tap, which is made to bottom, then the tap is used and screwed to the bottom, and the bottoming-tap follows. This is parallel the whole length of the thread, but the first three or four cutting edges should be carefully filed back, of

FIG. 45. METHOD OF BACKING OFF A TAP.

course before hardening, so that each one will cut a fair share of the thread. In some bottoming-taps this is not done, and all the work then falls upon one thread, and the tap is almost useless. When properly shaped, the bottoming-tap will cut a full thread to within a couple of turns from the bottom of the hole, that is if the taper and the plug-taps are properly shaped and have been properly used.

To give a good cutting edge taps require to be properly backed off, and machine-made taps are usually shaped so. An inspection of the illustration (Fig. 45) will make this process clear. When the tap has been properly threaded, as shown by the full lines in Fig. 45, it is chucked eccentrically at three different positions, as shown by the three centres placed around the original centre. From these new centres

the tap is shaped as shown by the dotted arcs: thus from the centre A the arc B C is made. This cuts away the thread at the back of the cutting edge, and relieves the tap of the considerable surface friction common to taps not backed off.

Before tapping shallow holes they should be enlarged at the bottom to the size of the thread when good work is required. The thread may then be cut easily as though the hole were a thoroughfare. This enlargement is not very difficult to effect at the time of boring the hole, by using a suitable tool to follow the drill. The ordinary flat drill may be made to bore considerably larger than its cross diameter if the point is out of centre. This circumstance is often made use of to clear a hole for tapping, the drill of correct size and with its point in the middle is used to drill a depth of about one diameter of the thread, and the same drill, though preferably another one, is ground so that its point is considerably on one side, and the drilling is continued with this drill for a slight distance. Or a special tool, cutting a groove round the circumference at the bottom of the hole, may be used.

Square taps, made by filing four flats on the threaded part, are now used only for small screws; the cutting edge thus produced is very bad in shape. Modern machinery produces the fluted tap, with three or four grooves milled lengthwise of the thread, and each one giving a good cutting edge at a cost that may compare with square hand-filed taps.

Three or four grooves are made in taps of all sizes. Three grooves being Whitworth's practice, and the one followed generally by English manufacturers, whilst four grooves are common in America. The form of groove generally adopted for the three grooved taps is a half-circle, the size being such as to make the grooves equal in width to the threaded portions between them. That is three-sixths of the circumference are milled away, and three-sixths of the thread are left. A cutter that is one-half the diameter of the tap in width, and that has its edge shaped to a half-circle, will be just right.

In this tap, used for threading wood, the cutting is all

done by two edges. A hole is made diameterwise, and the end is bored up, as shown in Fig. 46, to meet this hole. The cross hole is made on the ridge of the thread, and forms the cutting edges on two opposite sides; the shavings cut from the groove escape through the end boring.

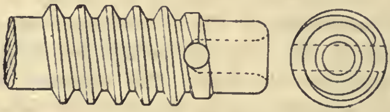


FIG. 46. TAP FOR SCREWING WOOD.

Taps of peculiar shapes are often made for special trades and purposes. The accompanying illustrations show some that are commonly used by gas-fitters. Fig. 47 is an ordinary tap, threaded to suit gas-burner screws, and made with a handle so that the tap is complete in itself. Fig. 48 is a similar tool to the last, but it has the horns of the handle made into implements, viz., a reamer and a turnscrew. Fig. 49 has a solid die in the centre, and from this radiate three

FIG. 47. HANDLED GAS-BURNER TAP.

implements: a tap, a reamer, and a turnscrew. This tool contains all the screwing appliances required in working gas fittings of any one small size.

Owing to the effects of hardening, taps for cutting square threads are often found to cut a nut which cannot be screwed

upon a screw cut to nominally corresponding gauge. To make the screws fit the nuts, a common practice is to thin the thread by cutting the groove wider, and to continue this

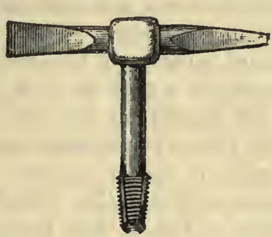


FIG. 48. HANDLED GAS-BURNER TAP WITH REAMER AND TURNSCREW.

thinning process till the screw will pass through the nut. Before any attempt is made to carry out this system of thinning the thread, great care should be taken to ensure

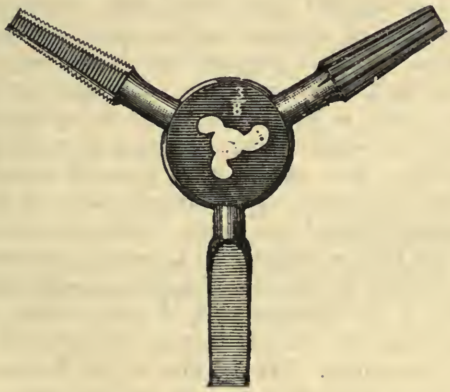


FIG. 49. THREE-BRANCH COMBINATION GAS-BURNER TOOL.

accuracy in the diameters, both of top and bottom of thread. The reason why a square thread shows the discrepancy in pitch of screw and nut much more than an angular thread does,

is easy to see in Fig. 7. A slight alteration in the diameters of the angular-threaded screw and nut will enable threads slightly differing in pitch to be screwed together; altering the diameters of square-threaded screws and nuts does not affect the agreements of pitch in any way. When a square-threaded screw has been thinned sufficiently to allow it to screw into a nut, and show apparently a good fit, it is really only bearing upon the first and last threads in the nut. This reduces the bearing surface of the nut to two threads only, when the length of the nut would make it appear to have, perhaps, eight or ten times that bearing surface. The wear being proportional to the bearing surface, it follows that the durability of a nut is decreased when the pitch of the thread in it differs from that of the screw which it is supposed to fit, and that this decrease is in proportion to the difference. The bearing of the screw-thread being upon the two end threads of the nut only, these soon wear, and the screw speedily shows lost motion.

Cutting a left-handed male screw with a right-handed tap reads almost like an erroneous statement; but it can be done. Though there are other cheaper and better ways of doing this, as explained elsewhere in this book, this method of producing the result is here given, as it is often a poser to young hands at screw-cutting. Take a die-stock of suitable size, remove the dies, and in their place fit a pair of hardwood blocks. At about the middle of one block bore a hole to the tapping size of the screw to be cut, and into this screw the tap that is intended to be used. Remove this tap, and cut V-notches in the blocks at those points which would be threaded in an ordinary pair of dies. Make one notch extend into the hole already tapped through, and make this notch to a wide angle. Put the dies in the dic-stock, and the tap in its hole; place it so that one of its cutting edges lies in the V-notch, and a rod of metal can then be threaded with a left-handed screw. By taking care to start right, the notch in the block opposite the tap will become impressed with the thread after one or two turns, and will then guide the dies, the tap doing the cutting.

A left-handed thread can be cut in a hole by means of a tap made with an ordinary right-handed screw-plate or dies. Having threaded a piece of steel in the usual way, the way to prepare it for cutting a left-handed thread is as follows: File away all the thread, except at two diametrically opposite points, at which the full thread is to be left in the form of a narrow ridge of teeth. This steel, if hardened and tempered after making the point tapering as usual with taps, can be used to cut a left-handed thread by simply screwing it into the hole in the reverse direction to the usual one. Care must be taken to start the tap fairly on its way during the first two or three turns, as, owing to the bulk of the thread having been removed from the circumference of the top, there is no guiding surface. It is owing to this guiding surface having been removed that the tap can be used in either direction, and left- or right-handed threads cut with it at pleasure, provided it is started in the required direction.

The work that can be done with properly-made taps is exemplified by the following records: With a $\frac{3}{4}$in. tap 18,800 cold-pressed nuts were tapped without any difference being perceptible in the size of the nuts; with a $\frac{5}{8}$in. tap 16,260 nuts were tapped, and with a $\frac{1}{2}$in. tap 18,000 nuts. It is authoritatively stated that a tap with a properly flattened top and root of thread will cut ten times as many nuts as will one with the simple V-thread, without appreciable change of size as compared with a standard gauge. Taps $\frac{3}{16}$in. diameter have been used to cut 120,000 nuts, when the principle mentioned on page 10 has been adopted, without any practical variation in the size of the first and last nut.

CHAPTER VIII.

CUTTING SCREWS ON THE LATHE.

SELF-acting screw-cutting lathes are used for cutting screw-threads when accuracy of pitch is required. This method is also the most general for making all screws that are above say ½in. diameter, and that are not made on screw-cutting machines.

The screw-cutting lathe is in its chief characteristics an ordinary lathe with certain necessary adjuncts, viz., a guide-screw the entire length of the lathe bed, and capable of being made to gear with, or run independent of a slide-rest which traverses the whole length of the bed. The rotations of the mandrel are imparted to the guide-screw by means of toothed wheels interchangeable on each and connected together by one or more intermediate toothed wheels. These are called change-wheels, and the usual set consists of 22 wheels, ranging from 20 teeth upwards increasing by 5 teeth, though sometimes by 10 teeth from 100 upwards, with one duplicate wheel of 40 or 60 teeth. By means of these wheels the ratio of the rotations of the mandrel and of the guide-screw can be governed, and in this way screws of any pitch within the range of the wheels can be accurately cut.

The tools used for threading screws are commonly made from square bar steel, and the illustrations in Fig. 50 show four shapes generally employed, two being for inside threads and two for outside threads. The tool shown on the left has a V point, and is intended for roughing out coarse external threads; the next tool has a similarly formed point, and is

intended for roughing out coarse internal threads. The next tool has its end flattened to about a third or a fourth of the width of the bar, and this narrower part is ground to shape for cutting fine threads: Fig. 51 is an enlarged illustration of this form of tool. The tool on the right in Fig. 50 is for cutting inside threads, the actual cutting point is a separate piece of steel made tapering, and driven tightly into a broached hole drilled diameterwise through the stock. All these lathe tools for threading screws are made by the BRITANNIA COMPANY, Colchester.

Fig. 51 is a plan view of a tool commonly used for cutting outside threads. The end only is shown, and the size given in the engraving is that suited for a general purpose tool, for

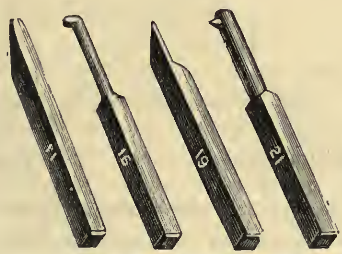


FIG. 50. LATHE TOOLS FOR THREADING SCREWS.

a lathe about 6in. centres. The cutting point is always made on the left of the bar, so that it will cut up to a shoulder conveniently when making a right-handed thread. If required for cutting left-handed threads the points should be made on the right side of the bar; but this is very seldom done. When the thread is to be cut close up to a large flange, or there is any other obstruction to the slide-rest, the tool, shaped like Fig. 50, should have the thinned part bent as shown in Fig. 51. When bent so the point can be conveniently placed so as to project beyond the edge of the slide-rest, and so allow work to be operated upon close to a shoulder, be it ever so wide. Even for general use a bent threading tool is often more convenient than a straight one.

The patent tool-holder (Fig. 53) is particularly suited for cutting inside threads. The square bar which is held in the slide-rest is bored through to allow a light steel rod to pass,

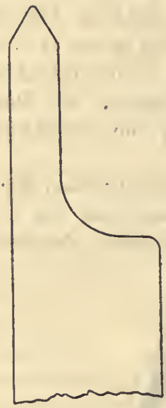


FIG. 51.
STRAIGHT THREADING TOOL.

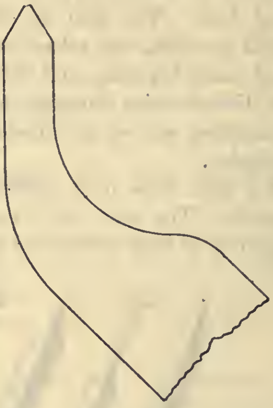


FIG. 52.
BENT THREADING TOOL.

and this is held by the bolt and washers shown at the left-hand end. The steel rod can be very readily bent at its end, and this part then filed to the shape wanted for the thread to be cut.

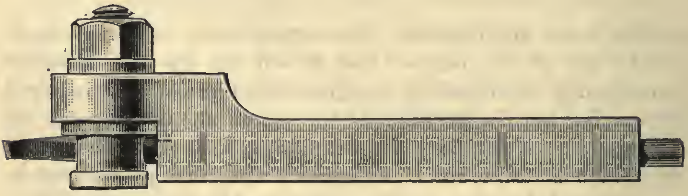


FIG. 53. PATENT TOOL-HOLDER FOR INSIDE THREADS.
(Made by Britannia Company.)

Fig. 54 shows a gauge useful in screw-cutting, by which the cutting tool may be set to suit the rake of the thread which differs with the same pitch of thread cut on different diameters, as illustrated by Fig. 6, and explained in connection with that

illustration. The gauge is made of sheet metal, and consists of the piece A, B, C, D, and the piece E, F, which are riveted stiffly together near the letter D, but so that they may be shifted. The edge E, F, is set to correspond with the rake of the thread to be cut, with the edges B and C parallel to the axis of the thread. Then the gauge is used to test whether the cutting-tool is ground to the proper inclination, the tool

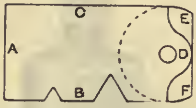


FIG. 54. GAUGE FOR MEASURING THREAD-RAKE.

resting on a flat surface, and the gauge applied on one side with B on the surface, and on the other side with C on the surface; or the edge A may be applied to the surface of a catch-plate, or any similar plane, mounted on the lathe, when this is an easier way of testing the tool.

In cutting external threads, when these are small in diameter, the cutting-tool may strike against the cone point in the poppet-head when the slide-rest is drawn back to the right preparatory to starting a fresh cut. If this occurs, a cone point having almost half of its diameter sliced away should be used. Fig. 55

FIG. 55. CONE POINT FOR SCREW-CUTTING.

illustrates such a cone point, seen from above when in its place. This allows the screw-cutting tool to pass freely along that part sliced away, so that even a comb screw-tool can be used and manipulated into position before its teeth are engaged in the thread.

When an ordinary driving-chuck and carrier are used in turning, the action of the single driving pin on the one tail of the carrier tends to bend the work running on the lathe centres. When the work is long and thin this action produces a very noticeable effect, and in cutting long slender screws it must be eliminated. A special form of driver-chuck, made on

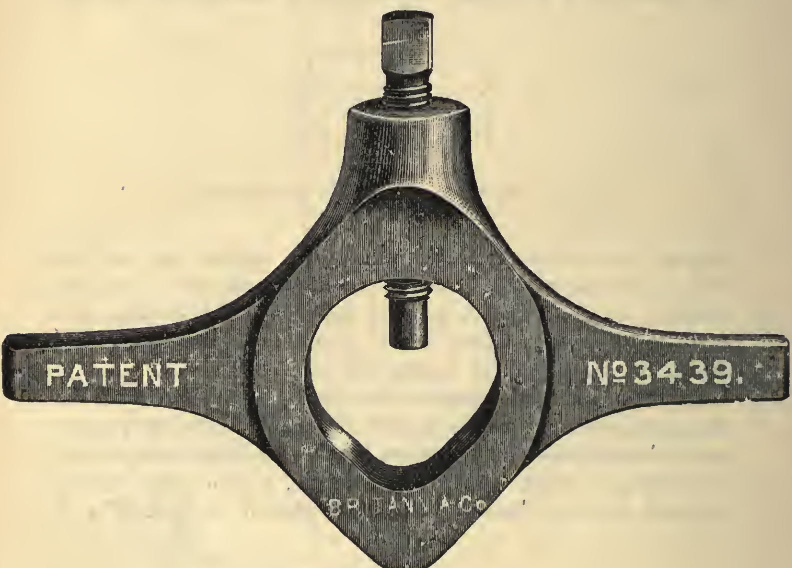


FIG. 56. DOUBLE-DRIVING CARRIER.

(Made by Britannia Company.)

the principle well known as Clement's driver, having two driving pins at diametrically opposite points, and arranged to each, press equally hard upon the two tails of a double-ended carrier. An excellent carrier for this purpose is shown at Fig. 56; the two arms engage with the two pins of the driver-chuck, and thus the pinching screw escapes the bending force which often renders the screw useless.

The tool used for cutting a thread in a screw-cutting lathe requires to be withdrawn from the cut at the end of every trip, so that it may be free of the work, and quickly brought back to take another cut. It is often difficult to re-adjust the tool properly in cut after withdrawing it unless some appliance is used for the purpose. A divided collar to the slide-rest screw is often used as a guide, but Fig. 57 shows an attachment made specially for the purpose. This appliance is intended to be bolted upon the cross slide of the slide-rest, and the nib, projecting from the nut shown in the centre of Fig. 56, butts

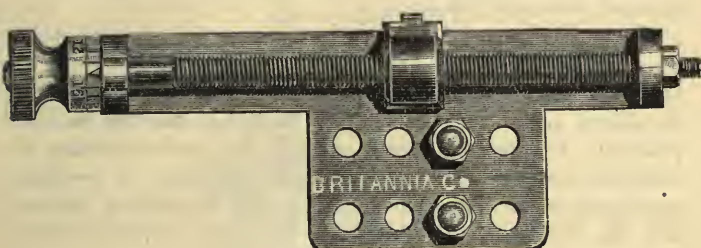


FIG. 57. SCREW-CUTTING GUIDE.

against a stud in the fixed part of the rest. It can be used for both inside and outside threads, and while one cut is being run this appliance can be adjusted for the next. By using this guide, which is made by the BRITANNIA COMPANY, Colchester, the depth of cut can be regulated to a nicety, the greatest depth of cut can always be taken without fear of breaking the tools, or tearing the work from between the centres. This useful appliance can be attached to any lathe, and is even very serviceable on an ordinary slide-rest not available for screw-cutting, but used simply as an adjustable stop.

When the screws being cut on the self-acting lathe are very long, some appliance is necessary to support the work against the thrust of the tool from which the long thin work would bend away. A back-stay is used for this purpose, and the same appliance also serves a like object when turning slender

rods of any kind. The back-stays commonly fitted on lathes are very diverse in form, but essentially they consist of a piece, usually of cast-iron, which is fixed to the slide-rest, and is arranged to hold movable jaws, in contact with the work. These jaws are even more various in their forms than the main piece of a back-stay. A plain right-angled notch, cut in the corner of a steel plate is, however, quite effective in most cases. This notch is placed with its sides touching the work on its far and top sides, and is fixed in that position, at a point near that at which the tool acts on the work. The bearing afforded by the notch stiffens the work against the cut and prevents it bending.

The cutting-tool and the back-stay may both be susceptible of some flexibility under the severe strain of the work. When this occurs, the roundness of the work and the truth of the thread cut upon it will both suffer. In lathes that are intended primarily for turning long and slender work—shafting for example—and to which an efficient back-stay is essential, arrangements are often made for rigidly connecting the tool and the back-stay. This prevents the strain mentioned above from operating.

Long screws that are intended to serve as guide-screws, require to be further treated after being cut with a tool in the slide-rest. Trifling errors will remain, owing chiefly to want of perfect uniformity in the material operated upon. To regulate the diameter and the thread form it is well to pass a solid die over the screw. This die will not help to improve the thread-rate, but, in fact, will act detrimentally to it, therefore only the least possible quantity of work should be left for it to do.

The screw-cutting lathe will be best described by illustrations of typical machines, selected from the catalogue of the BRITANNIA COMPANY, which are described fully in the accompanying specifications.

No. 13 LATHE. See Fig. 58.

Specification of improved Self-Acting, Sliding, and Screw-Cutting Gap Bed Lathe, of superior finish, best material and

workmanship. 3in. centre, 30in. gap bed; the head-stock is back-geared, the mandrel is cast steel with conical necks, steel lock-nuts and back centre, cone pulley, turned 3-speeds for gut-band, fitted with reversing motion for cutting right and left-hand screws; compound slide on carriage, with long bearings, accurately fitted and scraped to bed, and well gibbed. The top slide is made to swivel, and is graduated to 50deg. each side of centre, to turn cones to any desired angle; strong tool holder

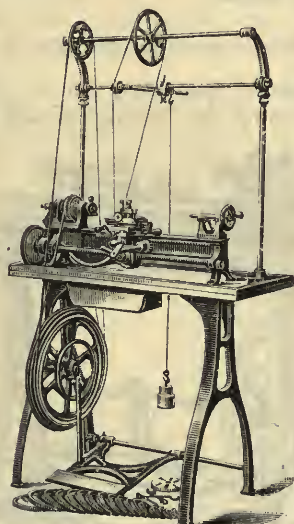


FIG. 58. LIGHT SCREW-CUTTING LATHE, 3IN. CENTRES.

with steel screws; tail stock of good design with tubular barrel, square thread traverse screw, bright turned hand-wheel. The bed is machine-planed, $3\frac{1}{2}$in. on face, $2\frac{3}{8}$in. deep with gap $2\frac{1}{4}$in. deep, and $2\frac{7}{8}$in. wide. The leading screw is steel, $\frac{7}{8}$in. diameter, $\frac{1}{4}$in. pitch, accurately cut; the gun metal nut is in halves to detach, and lathe is fitted with rack and pinion for quick traversing motion. A full set of 22 change-wheels to cut from one to sixty threads per inch, fitted with face plate, catch-

plate, steel centres, double spanner, and mounted on an iron stand with polished walnut top and drawer, turned flywheel 20in. diameter with 4 speeds, treadle motion, &c., complete. Measures between centres 19in., swings $10\frac{1}{2}$in. by $2\frac{7}{8}$in. in gap, 6in. over the bed, and $4\frac{1}{2}$in. over the carriage. Total weight, about 190lbs. Price complete, £15 15s. The same with 3ft. gap-bed, £16 16s. For ornamental turning, it is fitted with over-head motion, including ornamental drill spindle, as above illustration, £5 5s. extra.

NO. 14 LATHE. See Fig. 59.

This is an improved Self-acting Sliding and Screw-cutting Lathe of new design of $3\frac{1}{2}$in. centre and with 3ft. 6in. gap-bed.

FIG. 59. SCREW-CUTTING LATHE, $3\frac{1}{2}$IN. CENTRES.

The fast head-stock is well constructed with back gearing, hard steel mandrel, conical neck, adjusting cone at back end to take up wear, and running in hardened steel collars, 3-speed cone pulley for gut-band and fitted with reversing gear to cut right or left-hand screws. The loose head-stock has a steel cylindrical barrel, a left-hand square thread traverse screw, and bright turned hand-wheel; best steel centres, cone-fitted.

The saddle is strongly made, with flush top and T grooves for bolting down work, for boring, well scraped and fitted to bed, with adjustable strip to take up wear, and carries a compound slide-rest of most modern design, swivelling, and graduated to turn at any angle; swivelling tool-holder.

The bed is cast-iron, V edges, all machine planed, 3ft. 6in. long, $4\frac{3}{4}$in. on face, $3\frac{3}{4}$in. deep, with gap 5in. wide and $3\frac{3}{4}$in. deep, with bridge piece properly fitted. The leading screw is steel, accurately cut $\frac{1}{4}$in. pitch and one inch diameter, with double gun-metal nuts, disengaging by eccentric motion, and the saddle is fitted with rack and pinion for quick traversing motion.

The bed is planed at bottom and firmly bolted on to strong cast-iron standards, planed at top faces.

The crank-shaft and treadle-shaft run in self-adjusting swivelling bearings. The treadle is made with three cast-iron arms and bright turned shaft and connected to the bright turned crank-shaft by anti-friction chain and roller. The driving-wheel is 24in. diameter, turned bright with three top speeds and a small speed for slow motion. A polished tool-tray is neatly fitted between the standards, extending back and front to hold tools, small work, &c. A full set of 22 change-wheels, 14 pitch $\frac{5}{8}$in. face, face and catch plates, eccentric hand-rest and 2 tees, spanners, keys, &c., &c. Will admit 25in. between centres, $5\frac{1}{4}$in. diameter over saddle, 7in. over bed and $14\frac{1}{4}$in. in the gap. Height from centre to floor is 3ft. 8in. Approximate weight, 430lbs. Price, complete, £18 18s. If with cone-speed and driving-wheel for flat belt, 21s. extra. Over-head motion, for ornamental turning, £5 5s. extra.

No. 15 Lathe. See Fig. 60.

Self-acting Sliding and Screw-cutting, with 4ft. gap-bed, back geared head-stock, cast steel mandrel, conical necks running in gun-metal collars, steel lock nuts and back centre, cone pulley, turned 3 speeds for gut-band, fitted with reversing motion for cutting right or left-hand screws. Compound slide-rest with long bearings, accurately fitted to bed. The

I 2

top slide is made to swivel, and is graduated to 50deg. each side of centre to turn cones to any angle. The tailstock has cylinder barrel, square thread, steel traverse screw, bright turned hand-wheel.

The bed is accurately planed, and is 6⅛in. wide, and 4¼in. deep. The gap is 4¼in. deep. Steel leading screw 1⅛in. diameter, and ¼in. pitch; the gun-metal nut is in halves to detach. The lathe is fitted with rack and pinion for quick traverse. A full set of 22 change-wheels, to cut from 1 to 60 threads per inch, is fitted with steel centres, face-plate,

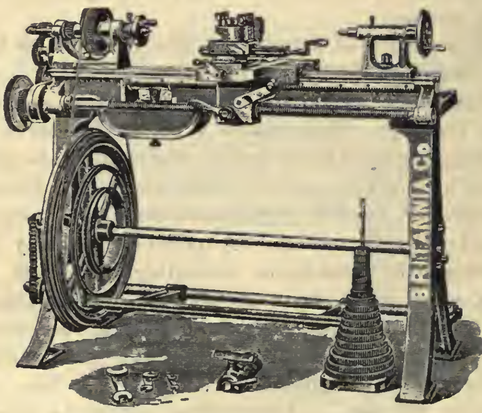


FIG. 60. SCREW-CUTTING LATHE, 4IN. TO 5IN. CENTRES.

catch-plate, and double spanner. Strong iron stand with improved treadle motion, with adjustable outside crank and friction rollers, or with ordinary crank and pitman. The 4ft. Lathe measures between centres 2ft. 6in., swings 1ft. 4in. in gap. The fly-wheel is counterbalanced and has 5 speeds. Weight of 4in. lathe about 5cwt.

These lathes can be fitted with over-heads for steam power at same price as for foot power. When for steam power a flat band is preferable. Price, with 4in. centre, £25 4s.; 4½in., £26 15s. 6d.; 5in., £28 7s. If self-acting and surfacing

by leading screw, extra £4. If with flat speed pulleys, 21s. extra. Set over poppet, 30s.

No. 16 Lathe. See Fig. 61.

Self-acting Sliding and Screw-cutting Lathe, with cast-iron gap-bed accurately planed and surfaced, and bridge piece fitted to gap; double-geared headstock; steel spindle with conical neck; hard steel or gun-metal collars; reversing motion for cutting right and left-hand screws; the loose head has

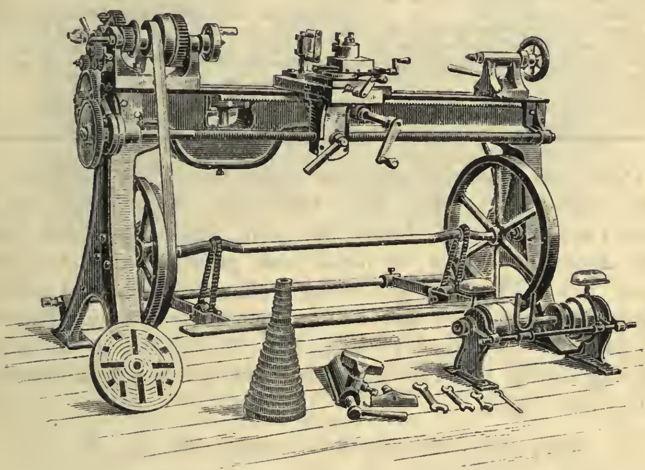


Fig. 61. Screw-cutting Lathe, 5in. to 6in Centres

cylinder barrel and left-hand traverse screw, and made to set over for taper turning if required; steel leading screw, accurately cut, and extending full length of bed, with double clam gun-metal nut-gripping screw at top and bottom; saddle with long wings, flush top, and grooved for bolting work to when boring; quick hand traverse by rack and pinion; compound slide-rest to swivel to any angle, graduated for turning conical, and steel draw-screws; back following stay; catch and face plates; twenty-two change wheels; index plate; treadle

motion; screw keys, &c., &c. All materials and workmanship guaranteed. The 5ft. Lathe measures 3ft. 2in. between centres.

DIMENSIONS.	5in. CENTRE.	6in. CENTRE.
Length, breadth, and depth of bed	5ft. by 7in. by 5½in.	6ft. by 7in. by 5½in.
Width and depth of gap	6½in. by 5in.	6½in. by 5in.
Length between centres and diameter to swing in gap....................	3ft. 2in. by 20in.	3ft. 10in. by 22in.
Diameter and pitch of leading screws	1¼in. by ¼in.	1¼in. by ¼in.
Surfacing shaft	1in.	1in.
Number and width of speed on cone pulley	3 speeds 1¼in. wide	3 speeds 1⅜in. wide
Diameter of largest and smallest speed	6¼in. and 3¼in.	6¾in. and 3¼in.
Width on face and pitch of gearing....	1¼in. and ⅜in.	1¼in. and $\frac{7}{16}$in.
Diameter of large and small gear wheels	6¾in. and 2½in.	7⅜in. and 2½in.
Diameter of nose of steel mandrel	1¼in.	1⅜in.
Pitch of the 22 change wheels	¼in.	¼in.
Approximate weight..................	5ft., 9cwt.	6ft., 10½cwt.

Price, 5in. centre, 5ft. bed, £31 10s.; 6ft., £33 10s.; 7ft., £35 10s.; 8ft., £37 10s.; 6in. centre, 5ft. bed, £33 14s.; 6ft., £35 14s.; 7ft., £37 14s.; 8ft., £39 14s. The above lathe can be fitted with grooved pulley for gut-band, £1s. 1s. less. If self-acting, sliding, surfacing and screw-cutting (by back shaft and leading screw), extra £4 4s. Poppe to set over for taper turning, £1. The above is as mad for the British Government. The leading screw and wearing parts are steel.

HEAVY SCREW-CUTTING LATHE. See Fig. 62.

Self-acting, Sliding, Surfacing, and Screw-cutting Lathe (12in. centre, 12ft. gap-bed), fitted with double-geared fast head-stock, steel mandrel, conical necks, gun-metal bearings, reversing motion for cutting right and left-hand screws; the loose headstock is fitted with cylinder barrel and left-hand square thread traverse screw, bright turned hand-wheel, and can be made to set over by transverse slide motion for taper turning, if desired. The saddle has a flush top and T grooves for bolting work for boring purposes, compound slide-rest, made to swivel to any angle for surfacing, and graduated for turning conical. The bed is accurately planed and surfaced, and provided

with movable bridge piece for gap, box end at left-hand, and firmly bolted to strong standard with planed faces at right-hand end. The metal is carefully distributed, so that the lathe is quite rigid under the heaviest cutting strain; the leading screw is of steel, accurately cut, and extends full length of bed. It has a double clam gun-metal nut actuated by eccentric movement to engage and release the saddle, the latter having also a quick hand traverse by rack, pinion and double purchase

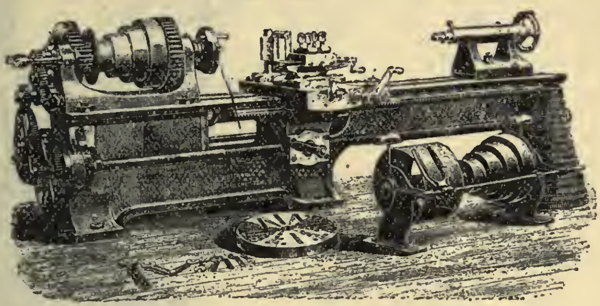


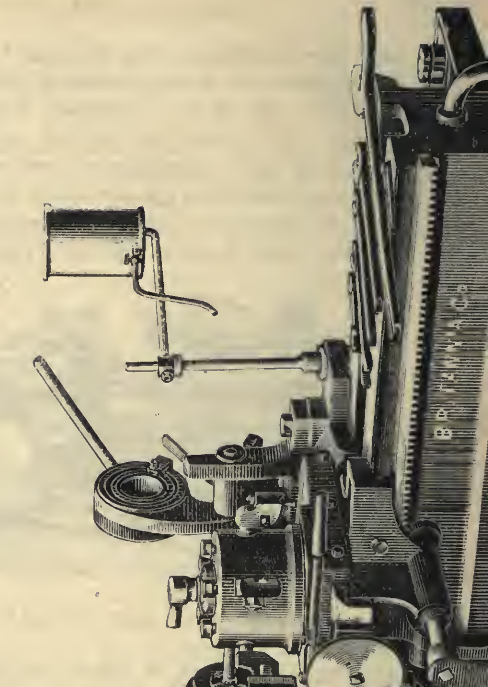
FIG. 62. HEAVY SCREW-CUTTING LATHE, 12IN. CENTRES.

gearing. The lathe is fitted complete with back traversing stay, 22 change-wheels, index-plate, 24in. face-plate, catch-plate, and top driving apparatus complete, screws, keys, &c., &c. All of the best materials and workmanship.

DIMENSIONS.—Bed, 19in. wide × 13in. deep; gap, $19\frac{1}{2}$in. wide × $11\frac{1}{2}$in. deep swinging 47in. diameter; leading screw, $2\frac{1}{2}$in. diameter, $\frac{1}{2}$in. pitch; back surfacing shaft, $1\frac{5}{8}$in. diameter; extreme length between centres, 6ft. 8in.; cone pulley, 4 speeds, $3\frac{7}{8}$in. wide; largest speed 16in. and smallest $6\frac{7}{8}$in. diameter gearing, $3\frac{1}{4}$in. wide × $1\frac{1}{8}$in. pitch; largest, $17\frac{1}{4}$in.; pinion, 6in. diameter; steel mandrel, $2\frac{1}{2}$in. body, $2\frac{3}{4}$in. nose; change-wheels, 22; $\frac{1}{2}$in. pitch; approximate weight, 4 tons.

CHASING LATHE. See Fig. 63.

Improved Hollow and Open-sided Spindle Lathe with Capstan Rest, for quickly and cheaply producing screwed studs, joint



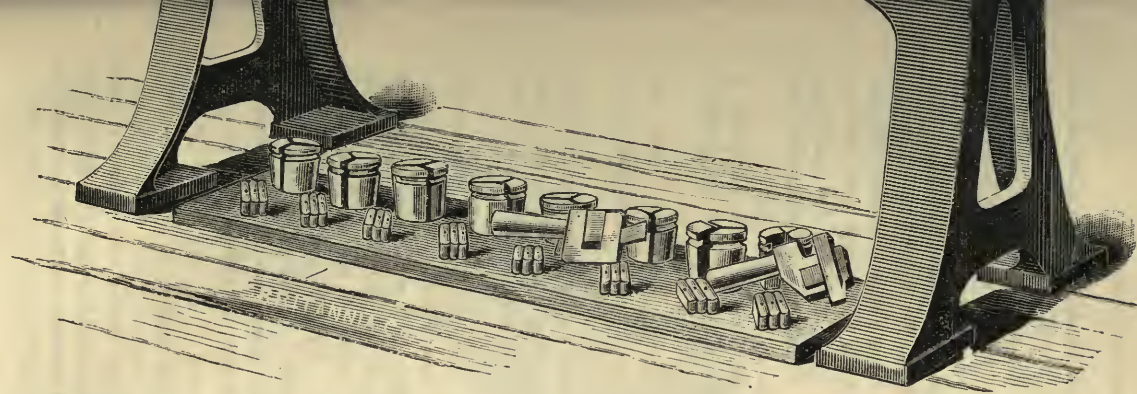


FIG. 63. IMPROVED HOLLOW-MANDREL LATHE, ADMITTING ROD METAL OF ANY LENGTH, WITH CAPSTAN REST FOR TURNING STUDS PINS, &C., AND CHASING SCREWS, &C., MADE BY THE BRITANNIA COMPANY, COLCHESTER. (For particulars see pp. 119-122.)

pins, and small turned fittings of all kinds, usually done in an ordinary lathe. By means of this machine these can be made uniformly, far quicker, and by cheap labour, so that the machine soon repays its cost. It will turn, point, and chase studs at one operation by means of the capstan rest.

The head-stock is constructed of two parts, accurately fitted to slide one over the other to adjust for taking up wear of spindle, the latter being made of steel, with hardened conical neck, with hole through its length to take long rods, and its sides open to enable headed bolts to be inserted for screwing, and its nose fitted with a coned chuck and gripping-dies for 9 sizes of tubes or rods, from $\frac{1}{4}$in. to 1in. diameter.

The saddle is arranged with transverse slide, carrying a capstan tool holder, fitted with five tools, adapted for sliding, rounding points, surfacing, parting, &c.

The saddle is also fitted with quick traverse by rack and pinion, also self-acting traverse by fine thread leading screw with convenient disengaging nut.

On the saddle is mounted the screwing arrangement with die-box and adjustable dies for screwing $\frac{1}{4}$in., $\frac{5}{16}$in., $\frac{3}{8}$in., $\frac{7}{16}$in., $\frac{1}{2}$in., $\frac{5}{8}$in., $\frac{3}{4}$in., $\frac{7}{8}$in., and 1in., and hinged to throw back out of the way when not in action.

The bed is of trough section to catch the soap and water, and constructed to conveniently draw it off.

The whole is of best materials and workmanship, and of the following dimensions: Height of centre, 7in.; driving cone, 4 speeds, $2\frac{3}{4}$in. wide; feed cones, 3 speeds, $1\frac{1}{2}$in. wide; length and width of bed, 5ft. by $12\frac{1}{2}$in.; largest, 13in. diameter; smallest, 7in. Complete over-head motion with reversing motion, soap-sud can and stand, screw keys, spanners, &c., are included in the price. Price, complete, £72 10s.

Capstan, or Turret Slide-rests. See Fig. 64.

These Turret Rests, designed for use on any ordinary plain lathe, can be fitted to any lathe, and are great economisers of time for brass finishers and others, when large quantities of uniform size and shape, and cylindrical in section are to

be produced, giving many of the advantages of the expensive Turret Lathes.

The revolving head is constructed to hold five tools of any desired forms for sliding, surfacing, pointing, parting, &c., enabling all such operations to be done at one setting of the work, and if the rest be used in conjunction with a head-stock having a hollow spindle through which rods of metal may be passed, studs, joint pins, &c., with cheese or cup heads, or

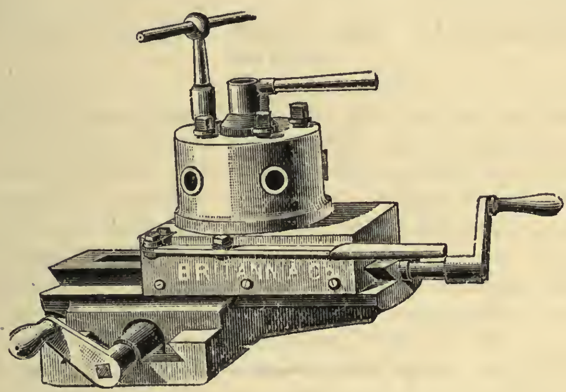


FIG. 64. TURRET HEAD SLIDE-REST.

(Made by Britannia Company.)

without heads, may be quickly and cheaply produced and cut off finished from the rod.

The "Capstan" or "Turret" Tool Holder is rotated by hand, held in desired position by lever and link motion (as seen in illustration) actuating a steel piston dropping into accurately fitted notches in a ring at the bottom of capstan, and the latter is then firmly locked in position by the handle at the top.

The rests have compound slides having longitudinal and transverse traverse, and are prepared to bolt securely to any ordinary plain lathe, or can be made to fit the saddle of a

screw-cutting lathe. Prices are as follows: For lathes having centres, 3in., £6; 3½in., £6 10s.; 4in., £7 10s.; 4½in., £9; 5in., £10 10s.; 6in., £12 15s. The illustration is that of the 6in. size.

In Chapter XII. will be found seven illustrations showing several stages in the manufacture of a bolt. The turret-head slide-rest is intended to be used with a series of tools, each one of which operates to advance the work one stage, as there explained.

CHAPTER IX.

ARITHMETIC AND RULES FOR CALCULATING WHEELS.

THE rules which govern the calculation of wheels required for cutting screws of any pitch are collected here for easy reference. These rules will be found more or less expanded in all treatises on arithmetic. They are summarised here concisely and apart from all other arithmetical information not directly bearing on these calculations.

Arithmetic is the science which treats of numbers, of the mode of expressing them, and of the various uses to which they may be applied in the practical affairs of life.

For general convenience and to save space, the following signs are generally used in all arithmetical operations:

+ (*plus*) shows that the number before which it stands is to be added. Example, 6 + 3, shows that 3 is to be added to 6, and the expression is read, "Six plus three." When numbers are added together the resulting number is called their sum. Thus 9 is the sum of 6 + 3.

— (*minus*) shows that the number before which it stands is to be subtracted. Example, 6 — 3, shows that 3 is to be subtracted from 6, and the expression is read, "Six minus three." When one number is subtracted from another the resulting number is called the remainder or difference. Thus 3 is the remainder of 6 — 3.

× (*into*) shows that the numbers between which it stands are to be multiplied together. Example, 6 × 3 shows that 6 is to be multiplied by three, and the expression is read, "Six

into three." Numbers that are multiplied together are called factors, the resulting number is called the product. The number to be multiplied is called the multiplicand, and the number by which it is multiplied is called the multiplier. Multiplication is a short way of making an addition. Example, 6×3 gives the same product as $6 + 6 + 6$, and also the same as $3 + 3 + 3 + 3 + 3 + 3$. From this it follows that when two numbers are multiplied together, it matters not which is taken as multiplicand or as multiplier.

$\div$ (*by*) shows that the number which stands before it is to be divided by the one which follows it. Example, $6 \div 3$ shows that 6 is to be divided by 3, and the expression is read, "six by three." When one number is divided by another the resulting number is called the quotient. Division is the method of finding how many times one number is contained in another, and bears the same relation to subtraction that multiplication bears to division.

$=$ (*equal*) shows that the numbers between which it stands, are equal in value to each other. Example, $6 + 3 = 9$ shows that 3 added to 6 equals 9, and the expression is read "six plus three equal nine."

π (*the Greek letter pi*) indicates the ratio of the circumference of a circle to its diameter. Diameters of circles are commonly expressed in simple digits, and their circumferences are called "Diameter $\times$ π." The problem of squaring a circle is still unsolved, and therefore an exact ratio of diameter to circumference is still undetermined, and the value of π is approximate only. This value has, however, been determined to some hundreds of decimals, and the following equivalents may be used according to the degree of accuracy required in calculations:

$$\pi = 3{\cdot}14159265358979323846264338327950 2884, \&c.;$$

or

$$\pi = 3{\cdot}1416 \text{ (too great by about 1 in 400,000);}$$

or

$$\pi = \frac{355}{113} \text{ (too small by about 1 in 13,000,000);}$$

or

$$\pi = \frac{22}{7} \text{ (too small by about 1 in 2,500);}$$

or

$$\pi = 3\tfrac{1}{7} \text{ (too small by about 1 in 2,500);}$$

or

$$\pi = 3 \text{ (too small by about 1 in 7).}$$

When a unit, whole number or integer, is divided into parts, one or any number of these parts is called a fraction A vulgar, or common fraction is expressed by two numbers placed one over and the other under a horizontal line. Example, $\frac{1}{2}$. The lower number is called the denominator, and it shows the number of parts into which the integer is divided. The upper number is called the numerator, and it shows the quantity of these parts which form the fraction. Example, $\frac{3}{4}$ shows that the integer is divided into four parts and that three of these parts form the fraction. A whole number may be expressed as a fraction by writing one as a denominator. Decimal fractions are explained on the next page.

A *proper* fraction is one having the numerator less than the denominator, so that the fraction represents less than a whole number. Examples, $\frac{1}{2}$, $\frac{7}{8}$.

An *improper* fraction is one having the numerator equal to or greater than the denominator, so that the fraction represents a whole number, or more. Examples, $\frac{2}{2}$, $\frac{8}{7}$.

A *mixed* number is one comprising a whole number and a fraction, and it may be converted into and expressed as an improper fraction. Examples, $1\frac{1}{2}$, $5\frac{1}{8}$.

A *compound* fraction is a fraction of a fraction. Examples $\frac{1}{2}$ of $\frac{1}{2}$, $\frac{1}{3}$ of $\frac{7}{8}$.

A *complex* fraction is one having a fraction for either the numerator or the denominator, or for both. Examples, $\frac{3\frac{1}{2}}{2}$, $\frac{\frac{1}{2} \text{ of } \frac{7}{8}}{5\frac{1}{2}}$.

In dealing with fractions the following rules are useful:

To reduce a mixed number to an improper fraction, multiply the whole number by the denominator of the fraction,

add the product to the numerator to form a new numerator, and retain the same denominator. Example, $2\frac{1}{2} = \frac{5}{2}$, because the whole number 2 × 2, the denominator, = 4, which added to 1, the numerator, = 5, and forms the new numerator; the old denominator 2 being retained.

The value of a fraction is not altered if the numerator and the denominator are *both* either multiplied or divided by the same number. Example, $\frac{1}{2}$ is the same value as $\frac{2}{4}$, and $\frac{6}{12}$ is the same value as $\frac{3}{6}$, &c.

Decimal fractions may be considered as vulgar fractions, which have for the denominator always 1, with cyphers added equal to the number of digits in the numerator. Thus decimal fractions have always 10 or some power of 10 as denominator.

In common integers the actual value of each figure depends upon its position relative to the digit on the right hand of the group of digits. Thus the right hand digit has its own proper value, and expresses so many units; but the digit standing second from the right is, from the mere change in its position, increased in value tenfold, and the same relative increase occurs in each successive digit, whatever number of figures may be written.

This fact is well understood by the veriest tyro in arithmetic, it is the first principle of common notation of decimal integers, by which are expressed numbers of any magnitude by means of ten digits only. The same method of notation, to the right of the digit expressing units, gives decimal fractions, commonly called decimals.

Everyone is familiar with decimal integers, yet comparatively few people understand decimal fractions, though these are actually the same in every respect, and need no additional knowledge whatever. In a group of integers every digit to the right is, merely from its relative position, decreased in value by one-tenth, and the same rate of decrease continues, if additional digits are added on the right of the last integer. To distinguish integers from decimals a point (thus ·) is placed between the last integer and the first decimal. The position of this decimal point fixes the value of the digits.

The following table will explain this clearly:

Hundred thousands	Ten thousands	Thousands	Hundreds	Tens	Units	Decimal point	Tenths	Hundredths	Thousandths	Ten thousandths	Hundred thousandths	Millionths.
6	5	4	3	2	1	·	1	2	3	4	5	6
		Integers.							Decimals.			

The addition of cyphers to the right of a decimal does not alter its value, nor does prefixing cyphers to an integer; but prefixing a cypher to a decimal decreases its value tenfold, just as adding a cypher to an integer increases its value tenfold.

Decimals are added, subtracted, multiplied, and divided in the same way as explained of integers. The only special thing requiring attention being the correct placing of the decimal point. In dealing with whole numbers we take care to distinguish the relative values of units, tens, thousands, &c., and do not say 1 unit + 1 ten + 1 hundred = 3. So in dealing with decimals we must take equal care to distinguish the relative values of tenths, hundredths, thousandths, &c. In reading decimals it is usual to simply say "point," and name the digits. Example, ·246731 should be read "Point, two, four, six, seven, three, one."

The table of wheels for screw-cutting, given in Chap. X., will be found to contain pitches to suit every ordinary purpose, and the following rules will answer for others.

Universal Rule for finding the Change-wheels for any pitch whatever: Find the distance that contains a complete number of threads in the screw to be cut, also find the number of threads in the same distance on the guide-screw. This will give the ratio which exists between the screw to be cut and the leading screw, and the same ratio must also exist between the driven and the driving wheels. Therefore, multiply both

terms of the ratio by some one number that will produce quotients equal to some available change-wheels. If two wheels will not commensurate the ratio, four or more will do so unless the ratio is expressed by prime numbers that cannot be measured by the wheels. In this case an approximation sufficiently near for practical purposes can be determined.

The formulæ for calculating change-wheels and the screws they will cut, are:

$$P \times n = \frac{D}{F}$$

$$\frac{d}{g} \times a = \frac{D}{F}$$

$$r = \frac{P}{n} = \frac{D}{F}$$

$$r = \frac{n}{P} = \frac{F}{D}$$

$$r = \frac{d}{g} = \frac{P}{g}$$

$$R = \frac{P}{n} = \frac{P}{g} = \frac{d}{g} = \frac{P}{p}$$

In which

- P = pitch of screw to be cut.
- d = pitch of screw to be cut in decimals.
- p = pitch of guide-screw.
- g = pitch of guide-screw in decimals.
- D = driving-wheel or wheels.
- F = following or driven wheel or wheels.
- n = number of threads per inch in guide-screw.
- r = ratios between guide-screw and screw to be cut and between driving and driven wheels.
- R = ratio of rotations of mandrel to each one of guide-screw.
- a = any integer or integers which will reduce d and g to whole numbers.

To prove the Wheels: Multiply all the driving-wheels together, and all the driven wheels together, then divide the greater by the less to get the smallest figures representing the ratio

between driving and driven. These figures will be the same as those representing the ratio between the guide-screw and the screw to be cut expressed in the smallest figures.

Cutting double, treble, or more Threads: Calculate the train of wheels so that it contains one driver that is a multiple of the number of threads required. Place this driver on the mandrel, mark equidistant teeth in this wheel according to the number of threads required, and mark one space in the next driven wheel. Proceed to cut one thread with one marked tooth in the marked space. When completed, draw the mandrel-wheel out of gear and replace it with another marked tooth in the marked space, and proceed to cut the second thread. Continue the same processes till all the threads are completed.

Left-handed Threads: These are cut with the same trains for given pitch as are right-handed threads, but an extra wheel is interposed in the train. This idle wheel does not alter the ratio of motion in the train, but it reverses its direction.

To Measure Fractional Thread-rates: When a difficulty occurs in measuring the number of threads in an inch, owing to there being a fractional part, lay the rule along the screw and note where the threads correspond with any number of whole inches. Then count the number of threads and divide by the number of inches, which will show the number of threads (and fractional parts) in one inch. It is, however, usual to speak of a screw as having a certain number of threads in a certain number of inches. For example, thirteen threads in 3in. and not as having $4\frac{1}{3}$ threads per inch, which is the same.

Surfacing Feed: When the surfacing motion is driven from the guide-screw by a worm-wheel and bevel-wheels, the ratio of the surfacing motion is found by multiplying together all the driving-wheels, and also all the driven wheels, also multiplying each by the pitch of the screws, either driving or driven, which serve to transmit the motion. This ratio is reduced to its lowest terms, and is constantly used in calculating the wheels required.

Turning Cones by self-acting motion: The surfacing motion of a slide-rest can be made to act simultaneously with the traversing motion of the lead-screw, and these combined

motions produce a cone. First find how many revolutions the back shaft must make to move the surfacing slide $\frac{1}{2}$in., which is equal to a difference of 1in. in diameter of the work. This gives the ratio of motion, and change-wheels are calculated in the same way as for screw-cutting.

The following table shows nearly 1000 trains of wheels calculated for cutting a large variety of thread-rates having an entensive range.

The number of threads per inch to be cut is shown in the first (left-hand) column. They range from a twist of $\frac{1}{16}$ of a turn per inch to a fine thread of 100 turns per inch, and give 148 different thread-rates.

The pitch or distance between the threads to be cut is shown in the three right-hand columns. The first column (on the right) gives inches or fractions of an inch, from 16-in. pitch, that is one turn in 16in. to $\frac{1}{100}$-in. pitch, that is 100 turns per inch; 151 different thread-rates are given. The second column (from the right) gives the pitches in inches and decimal fractions of an inch; it includes the same range, and gives 219 different thread-rates. The third column (from the right) gives the pitches in millimètres, ranging from over 406-mm. pitch to $\frac{254}{1000}$-mm. pitch, and gives 219 different thread-rates in millimètres.

The trains of change-wheels for cutting these thread-rates are shown in the central columns. The first group gives the wheels for guide-screws having four threads per inch, which are usual in small screwing-lathes. The second group gives the wheels for guide-screws having two threads per inch, which are usual in large screwing-lathes.

Thus it is quite easy to at once read off the wheels required for cutting screws either of so many threads per inch, or of any pitch, fractional, decimal, or metric.

CHAPTER X.

TABLE FOR SCREW-CUTTING.

Threads per inch to be cut.	GUIDE-SCREW, ¼in. PITCH.		GUIDE-SCREW, ½in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
$\frac{1}{16}$	—	—	120×120 150× 80	20×20 15×25	16	16	406·4
$\frac{1}{15}$	—	—	120×100 150×100	20×20 20×25	15	15	381·
$\frac{1}{14}$	—	—	140×100	20×25	14	14	355·6
$\frac{1}{13}$	—	—	130×100	20×25	13	13	330·2
$\frac{1}{12}$	—	—	120×100 120× 80	20×25 20×20	12	12	304·8
$\frac{1}{11}$	—	—	120×110 110×100	20×30 20×25	11	11	279·4
$\frac{1}{10}$	—	—	120×100 100×100	20×30 20×25	10	10	254·
$\frac{1}{9}$	—	—	120× 90 100× 90	20×30 20×25	9	9	228·6
$\frac{1}{8}$	120×120	20×20	120× 80 100× 80	20×30 20×25	8	8	203·2
$\frac{1}{7}$	—	—	100× 70 120× 70	20×25 20×30	7	7	177·8
$\frac{1}{6}$	120×100 120× 80	20×25 20×20	90× 80 120×100	20×30 25×40	6	6	152·4

Threads per inch to be cut.	GUIDE-SCREW, ¼in. PITCH.		GUIDE-SCREW, ½in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
$\frac{2}{11}$	110×100 120×110	20×25 20×30	100× 55 110× 80	25×20 20×40	$5\frac{1}{2}$	5·5	139·7
$\frac{1}{5}$	100× 80 120×100	20×20 20×30	80× 75 100× 60	20×30 20×30	5	5	127·
$\frac{2}{9}$	100× 90 120× 90	20×25 20×30	90× 80 90× 70	20×40 20×35	$4\frac{1}{2}$	4·5	114·3
$\frac{1}{4}$	100× 80 120× 80	20×25 30×20	80× 60 80× 70	20×30 20×35	4	4	101·6
—	63×100 70× 90	20×20 20×20	63×100 70× 90	20×40 20×40	—	3·93	100·
$\frac{4}{15}$	100× 75 60×100	20×25 20×20	100× 60 80× 75	20×40 20×40	$3\frac{3}{4}$	3·75	95·25
—	63× 95 63× 76	20×20 20×26	63× 95 63× 76	20×40 20×32	—	3·74	95·
—	63× 90 63×108	20×20 20×24	63× 90 63×108	20×40 40×24	—	3·54	90·
$\frac{2}{7}$	100× 70 80× 70	20×25 20×20	50× 70 60× 70	25×20 20×30	$3\frac{1}{2}$	3·5	88·9
$\frac{8}{27}$	90× 60 90× 90	20×20 20×30	60× 90 90× 75	20×40 40×25	$3\frac{3}{8}$	3·375	85·72
—	63× 85 63×102	20×20 20×24	63× 85 63×102	20×40 24×40	$3\frac{7}{20}$	3·35	85·
$\frac{4}{13}$	100× 65 120× 65	20×25 20×30	65× 50 75× 60	20×25 25×30	$3\frac{1}{4}$	3·25	82·55
—	63× 80 63×100	20×20 20×25	63× 80 63×100	20×40 25×40	$3\frac{3}{20}$	3·15	80·

Threads per inch to be cut.	GUIDE-SCREW, $\frac{1}{4}$in. PITCH.		GUIDE-SCREW, $\frac{1}{2}$in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
$\frac{8}{25}$	100× 50 100× 75	20×20 20×30	100× 50 100× 75	20×40 30×40	$3\frac{1}{8}$	3·125	79·37
$\frac{1}{3}$	80× 75 80× 90	20×25 20×30	80× 60 80× 90	20×40 30×40	3	3·	76·2
—	63× 75 63× 90	20×20 20×24	63× 75 63× 90	20×40 20×48	$2\frac{19}{20}$	2·95	75·
$\frac{8}{23}$	115× 60 115× 80	20×30 20×40	115× 75 115× 50	50×30 25×40	$2\frac{7}{8}$	2·875	73·02
—	63× 70 63×105	20×20 20×30	63× 70 63×105	20×40 20×60	—	2·75	70·
$\frac{4}{11}$	110× 60 100× 55	20×30 20×25	110× 40 100× 55	20×40 25×40	$2\frac{3}{4}$	2·75	69·85
—	63×108 63×135	20×32 20×40	63×108 63×135	32×40 40×40	—	2·657	67·5
$\frac{8}{21}$	75× 70 60× 70	20×25 20×20	60× 70 75× 63	20×40 20×45	$2\frac{5}{8}$	2·625	66·67
—	63× 65 63× 78	20×20 20×24	63× 65 63× 78	20×40 20×48	—	2·56	65·
$\frac{2}{5}$	80× 75 100× 80	20×30 20×40	50× 60 60× 75	20×30 20×45	$2\frac{1}{2}$	2·5	63·5
—	63× 75 63×125	20×24 20×40	63× 75 63×100	24×40 32×40	—	2·46	62·5
$\frac{8}{19}$	95× 50 95× 60	20×25 20×30	95× 50 95× 70	25×40 35×40	$2\frac{3}{8}$	2·375	60·32
—	63× 60 63× 90	20×20 20×30	63× 60 63× 75	20×40 20×50	—	2·36	60·

Threads per inch to be cut.	GUIDE-SCREW, ¼in. PITCH.		GUIDE-SCREW, ½in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
—	63× 69 63×115	20×24 20×40	63× 69 63×115	24× 40 40× 40	—	2·26	57·5
$\frac{4}{9}$	90× 70 60× 90	20×35 20×30	60× 90 50× 90	30× 40 25× 40	$2\frac{1}{4}$	2·25	57·15
—	63× 55 63×110	20×20 20×40	63× 55 63×110	20× 40 40× 40	—	2·16	55·
$\frac{8}{17}$	60× 85 85×100	20×30 20×50	40× 85 50× 85	20× 40 25× 40	$2\frac{1}{8}$	2·075	53·97
—	63× 63 63×105	20×24 20×40	63× 63 63×105	24× 40 20× 80	—	2·067	52·5
$\frac{1}{2}$	75× 80 80× 90	25×30 20×45	60× 80 70× 80	30× 40 35× 40	2	2·	50·8
—	63× 50 63× 75	20×20 20×30	63× 50 63× 75	20× 40 30× 40	—	1·97	50·
$\frac{16}{31}$	90× 62 100× 62	24×30 20×20	50× 62 62× 75	20× 40 20× 60	$1\frac{15}{16}$	1·9375	49·21
—	63× 60 63× 90	20×25 25×30	63× 60 63× 90	25× 40 30× 50	—	1·889	48·
$\frac{8}{15}$	60×100 75×100	20×40 30×40	50× 60 50× 90	20× 40 30× 40	$1\frac{7}{8}$	1·875	47·62
$\frac{16}{29}$	60×145 75×145	30×40 30×50	45×145 60×145	30× 60 40× 60	$1\frac{13}{16}$	1·8125	46·04
—	63×115 63×115	20×50 25×40	63×115 63×115	40× 50 20×100	—	1·811	46·
—	63× 45 63× 90	20×20 20×40	63× 45 63× 90	20× 40 40× 40	—	1·77	45·

Threads per inch to be cut.	GUIDE-SCREW, $\frac{1}{4}$in. PITCH.		GUIDE-SCREW, $\frac{1}{2}$in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
$\frac{4}{7}$	60× 70 70× 80	20×30 20×40	50× 70 90× 70	25× 40 30× 60	$1\frac{3}{4}$	1·75	44·45
—	63× 55 63×110	20×25 25×40	63× 55 63×110	20× 50 40× 50	—	1·732	44·
$\frac{16}{27}$	60× 90 75× 90	20×40 20×50	45× 90 75× 90	30× 40 40× 50	$1\frac{11}{16}$	1·6875	42·86
—	63× 84 63×105	20×40 25×40	63×105 63× 84	40× 50 20× 80	—	1·653	42·
$\frac{8}{13}$	65× 80 65×100	20×40 25×40	65× 60 65×100	30× 40 40× 50	$1\frac{5}{8}$	1·625	41·27
—	63× 80 63× 40	20×40 20×20	63× 80 70× 90	40× 40 40× 50	—	1·57	40·
$\frac{16}{25}$	50× 75 60× 75	20×30 24×30	50× 75 75× 60	40× 30 40× 36	$1\frac{9}{16}$	1·5625	39·68
—	63× 78 63× 78	20×40 25×32	63× 78 63× 78	40× 40 20× 80	—	1·535	39·
$\frac{2}{3}$	60× 80 80× 90	20×40 20×60	80× 90 75× 80	40× 60 40× 50	$1\frac{1}{2}$	1·5	38·1
—	63× 95 63× 95	25×40 20×50	63× 95 63× 95	40× 50 20×100	—	1·49	38·
—	63× 37 63× 74	20×20 20×40	63× 37 63× 74	20× 40 20× 80	—	1·456	37·
$\frac{16}{23}$	60×115 75×115	30×40 30×50	40×115 45×115	20× 80 30× 60	$1\frac{7}{16}$	1·4375	36·51
—	63× 90 63× 90	20×50 25×40	63× 90 63× 90	40× 50 25× 80	—	1·416	36·

Threads per inch to be cut.	GUIDE-SCREW, ¼in. PITCH.		GUIDE-SCREW, ½in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven	Fractions of an inch.	Decimals of an inch.	Millimètres.
—	63× 70 63× 80	20× 40 24× 40	63× 70 63× 70	40× 40 20× 80	—	1·378	35·
$\frac{8}{11}$	55× 80 100×110	20× 40 40× 50	60× 55 55× 60	40× 45 30× 40	$1\frac{3}{8}$	1·375	34·92
—	63× 85 63× 85	20× 50 25× 40	63× 85 63× 85	40× 50 25× 80	—	1·338	34·
$\frac{16}{21}$	60× 70 70× 90	20× 40 30× 40	45× 70 70× 75	30× 40 40× 50	$1\frac{5}{16}$	1·3125	33·33
—	33× 63 66× 63	20× 20 20× 40	66× 63 63× 99	20× 80 40× 60	—	1·3	33·
—	63× 60 63× 80	25× 30 25× 40	63× 60 63× 80	30× 50 40× 50	—	1·26	32·
$\frac{4}{5}$	50× 80 75× 80	20× 40 20× 60	75× 80 75× 60	40× 60 30× 60	$1\frac{1}{4}$	1·25	31·75
—	63× 62 63× 62	20× 40 25× 32	63× 62 63× 62	20× 80 40× 40	—	1·22	31·
$\frac{16}{19}$	60× 95 75× 95	30× 40 25× 60	45× 95 30× 95	30× 60 20× 60	$1\frac{3}{16}$	1·1875	30·16
—	63× 60 63× 90	20× 40 30× 40	63× 60 63× 90	20× 80 40× 60	—	1·18	30·
—	63× 58 63×145	20× 40 20×100	63× 58 63×145	20× 80 40×100	—	1·14	29·
$\frac{8}{9}$	60× 75 60× 90	20× 50 30× 40	30× 60 30× 75	20× 40 20× 50	$1\frac{1}{8}$	1·125	28·57
—	63× 70 63× 70	20× 50 25× 40	63× 70 63× 70	40× 50 25× 80	—	1·102	28·

Threads per inch to be cut.	GUIDE-SCREW, $\frac{1}{4}$in. PITCH.		GUIDE-SCREW, $\frac{1}{2}$in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
—	63× 54 63× 81	20×40 30×40	63× 54 63× 81	20× 80 40× 60	—	1·063	27·
$\frac{16}{17}$	50× 85 70× 85	25×40 35×40	25× 85 50× 85	20× 50 40× 50	$1\frac{1}{16}$	1·0625	26·98
—	63× 65 63× 65	20×50 25×40	63× 65 63× 65	25× 80 40× 50	—	1·023	26·
1	40× 50 50× 60	20×25 25×30	30× 80 40× 75	20× 60 25× 60	1	1·	25·4
—	63× 50 70× 90	20×40 40×40	63× 50 70× 90	20× 80 40× 80	—	·984	25·
—	63× 90 63× 60	30×50 20×50	63× 90 63× 60	50× 60 40× 50	—	·945	24·
$1\frac{1}{16}$	60× 75 50× 75	30×40 25×40	50× 75 70× 75	80× 25 80× 35	$\frac{16}{17}$	·9375	23·81
—	63× 46 63×115	20×40 40×50	63× 46 63×115	40× 40 50× 80	—	·905	23·
$1\frac{1}{8}$	35× 80 70× 75	20×40 30×50	30× 70 40× 70	20× 60 20× 80	$\frac{8}{9}$	·875	22·22
—	63× 55 63×110	20×50 40×50	63× 55 63×110	40× 50 50× 80	—	·866	22·
—	63× 63 63× 63	20×60 30×40	63× 63 63× 63	40× 60 30× 80	—	·826	21·
$1\frac{3}{16}$	60× 65 65× 90	30×40 40×45	45× 65 60× 65	30× 60 40× 60	$\frac{16}{19}$	·8125	20·64
$1\frac{1}{4}$	50× 80 60× 80	25×50 30×50	80 60× 80	50 30×100	$\frac{4}{5}$	·75	20·32

Threads per inch to be cut.	GUIDE-SCREW, ¼in. PITCH.		GUIDE-SCREW, ⅛in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
—	63× 75 63× 60	25× 60 30× 40	63×75 63×60	50× 60 40× 60	—	·787	20·
$1\frac{5}{16}$	60 50× 60	20 25× 40	60 40×60	40 20× 80	$\frac{16}{21}$	·6875	19·05
—	63× 95 63× 95	40× 50 20×100	63×95 63×95	50× 80 40×100	—	·748	19·
—	63× 90 63× 45	40× 50 20× 50	63×90 63×45	50× 80 40× 50	—	·708	18·
$1\frac{3}{8}$	55 55× 75	20 25× 60	55 45×55	40 30× 60	$\frac{8}{11}$	·686	17·45
—	63× 85 63× 85	20×100 40× 50	63×85 63×85	40×100 50× 80	—	·669	17·
$1\frac{1}{2}$	80 50× 80	30 25× 60	80 50×70	60 35× 75	$\frac{2}{3}$	·666	16·93
—	63× 80 63× 60	40× 50 30× 50	63×80 63×60	50× 80 50× 60	—	·63	16·
$1\frac{5}{8}$	60× 80 40× 80	30× 65 20× 65	60×40 40×60	30× 65 30× 65	$\frac{8}{13}$	·615	15·9
—	63× 75 63× 90	40× 50 40× 60	63×75 63×90	50× 80 60× 80	—	·59	15·
—	45 60× 90	20 30× 80	45 30×75	40 50× 40	—	·562	14·28
$1\frac{3}{4}$	80 80×100	35 50× 70	80 40×60	70 30× 70	$\frac{4}{7}$	·555	14·11
—	63× 70 63×105	40× 50 40× 75	63×70 63×70	50× 80 40×100	—	·551	14·

Threads per inch to be cut.	GUIDE-SCREW, ¼in. PITCH.		GUIDE-SCREW, ½in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
$1\frac{7}{8}$	60× 80 40× 80	30× 75 20× 75	60× 40 30× 80	30× 75 25× 90	$\frac{8}{15}$	·533	13·5
—	63× 65 63× 65	40× 50 25× 80	63× 65 63× 65	40×100 50× 80	—	·512	13·
2	80 40× 75	40 30× 50	60 30× 60	60 20× 90	$\frac{1}{2}$	·5	12·7
—	63× 30 63× 60	20× 50 40× 50	63× 30 63× 60	40× 50 50× 80	—	·472	12·
$2\frac{1}{4}$	80 80× 60	45 30× 90	80 50× 80	90 60× 75	$\frac{4}{9}$	·441	11·29
—	70 35× 60	40 30× 40	35 30× 70	40 40× 60	—	·437	11·11
—	63× 55 63×110	25× 80 50× 80	63× 55 63×110	50× 80 80×100	—	·433	11·
$2\frac{1}{2}$	80 40× 60	50 50× 30	40 30× 80	50 40× 75	$\frac{2}{5}$	·403	10·16
—	63 70× 90	40 50× 80	63 70× 90	80 80×100	—	·393	10·
—	60 45× 50	40 25× 60	45 30× 50	60 20×100	—	·374	9·52
—	63× 95 63× 95	50× 80 40×100	63× 95 63× 76	80×100 80× 80	—	·374	9·5
$2\frac{3}{4}$	80 60×100	55 55× 75	80 20×100	110 50× 55	$\frac{4}{11}$	·362	9·23
—	63× 90 63× 45	50× 80 40× 50	63× 45 63× 90	50× 80 80×100	—	·354	9·

Threads per inch to be cut.	GUIDE-SCREW, ¼in. PITCH.		GUIDE-SCREW, ½in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
—	63×85 63×85	50× 80 40×100	63×85 63×68	80×100 80× 80	—	·335	8·5
3	80 80×75	60 90× 50	40 25×80	60 50× 60	$\frac{1}{3}$	·333	8·46
—	63 63×45	50 30× 75	63 63×45	100 60× 75	—	·315	8·
$3\frac{1}{4}$	80 60×80	65 65× 60	40 30×60	65 65× 45	$\frac{4}{13}$	·307	7·81
—	63×30 63×45	20× 80 30× 80	63×30 63×45	40× 80 60× 80	—	·295	7·5
$3\frac{1}{2}$	80 40×60	70 30× 70	40 30×60	70 45× 70	$\frac{2}{7}$	·286	7·26
—	63×35 63×70	40× 50 50× 80	63×35 63×70	50× 80 80×100	—	·275	7·
$3\frac{3}{4}$	80 40×60	95 30× 95	40 20×60	95 30× 95	$\frac{4}{15}$	·266	6·77
—	63×65 63×65	50× 80 40×100	63×65 63×52	80×100 80× 80	—	·256	6·5
4	40 30×40	40 20× 60	30 20×75	60 50× 60	$\frac{1}{4}$	·25	6·35
—	63×45 63×60	50× 60 50× 80	63×30 63×45	50× 80 60×100	—	·236	6·
$4\frac{1}{4}$	80 40×60	85 30× 85	40 20×70	85 35× 85	$\frac{4}{17}$	·235	5·97
$4\frac{1}{2}$	40 40×60	45 30× 90	40 30×60	90 45× 90	$\frac{2}{9}$	·222	5·64

Threads per inch to be cut.	GUIDE-SCREW, $\frac{1}{4}$in. PITCH.		GUIDE-SCREW, $\frac{1}{2}$in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
—	63× 55 63×110	40×100 80×100	63×55 63×33	80×100 60× 80	—	·216	5·5
$4\frac{3}{4}$	80 40× 60	95 30× 95	40 30×60	95 45× 95	$\frac{4}{19}$	·210	5·34
5	40 60	50 75	30 40	75 100	$\frac{1}{5}$	·2	5·08
—	63× 30 45× 70	40× 60 50× 80	63×30 45×70	60× 80 80×100	—	·197	5·
$5\frac{1}{4}$	20× 80 30× 80	30× 70 45× 70	30×40 20×80	45× 70 60× 70	$\frac{4}{21}$	·191	4·84
$5\frac{1}{2}$	40 40× 60	55 30×110	40 30×60	110 55× 90	$\frac{2}{11}$	·182	4·62
—	63× 45 63× 90	50× 80 80×100	63×45 63×36	80×100 80× 80	—	·177	4·5
$5\frac{3}{4}$	40× 50 40× 60	25×115 30×115	20×60 30×60	30×115 45×115	$\frac{4}{23}$	·174	4·42
6	40 60	60 90	25 30	75 90	$\frac{1}{6}$	·166	4·23
$6\frac{1}{4}$	30× 80 40× 80	50× 75 50×100	20×80 30×80	50×100 75×100	$\frac{4}{25}$	·159	4·06
—	63× 30 63× 20	50× 60 40× 50	63×30 63×20	60×100 50× 80	—	·157	4·
$6\frac{1}{2}$	40 30× 60	65 45× 65	20 25×40	65 50× 65	$\frac{2}{13}$	·154	3·91
$6\frac{3}{4}$	30× 80 40× 80	45× 90 60× 90	20×40 30×40	30× 90 45× 90	$\frac{4}{27}$	·148	3·76

Threads per inch to be cut.	GUIDE-SCREW, ¼in. PITCH.		GUIDE-SCREW, ½in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
7	40 30×40	70 30× 70	20 30×40	70 60× 70	$\frac{1}{7}$	·143	3·63
$7\frac{1}{4}$	63×35 63×70	50× 80 80×100	63×35 63×42	80×100 80×120	$\frac{4}{29}$	·137	3·5
$7\frac{1}{2}$	40 20×80	75 50× 60	20×60 30×60	50× 90 75× 90	$\frac{2}{15}$	·133	3·38
$7\frac{3}{4}$	32 40×60	62 62× 75	20×40 30×40	50× 62 62× 75	$\frac{4}{31}$	·128	3·27
8	40 20×75	80 50× 60	30 20×50	120 40×100	$\frac{1}{8}$	·122	3·175
$8\frac{1}{4}$	20×80 40×80	30×110 60×110	20×40 30×40	30×110 55× 90	$\frac{4}{33}$	·121	3·08
—	63×30 63×45	40×100 60×100	63×30 63×45	80×100 100×120	—	·118	3·
$8\frac{1}{2}$	40 50×60	85 75× 85	20 25×40	85 50× 85	$\frac{2}{17}$	·117	2·98
$8\frac{3}{4}$	20×80 30×80	50× 70 70× 75	20×40 20×80	50× 70 70×100	$\frac{4}{35}$	·114	2·9
9	40 30×60	90 45× 90	20 30×40	90 60× 90	$\frac{1}{9}$	·111	2·82
$9\frac{1}{4}$	20×80 30×80	50× 74 74× 75	30×40 20×40	74× 75 50× 74	$\frac{4}{37}$	·108	2·74
$9\frac{1}{2}$	40 25×80	95 50× 95	20 30×40	95 60× 95	$\frac{2}{19}$	·105	2·67
$9\frac{3}{4}$	20×40 20×80	30× 65 60× 65	20×40 25×40	60× 65 75× 65	$\frac{4}{39}$	·102	2·6

Threads per inch to be cut.	GUIDE-SCREW, ¼in. PITCH.		GUIDE-SCREW, ½in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
10	20 20×30	50 25× 60	20 20×40	100 50× 80	$\frac{1}{10}$	·1	2·54
—	63×30 63×45	60× 80 80× 90	63×20 63×25	80× 80 80×100	—	·098	2·5
10¼	20×80 40×60	50× 82 75× 82	20×40 20×60	50× 82 75× 82	$\frac{4}{41}$	·097	2·48
10½	20×80 25×80	60× 70 70× 75	20×40 20×50	60× 70 70× 75	$\frac{2}{21}$	·095	2·42
10¾	30×80 40×60	75× 86 75× 86	30×40 20×60	75× 86 75× 86	$\frac{4}{43}$	·092	2·36
11	40 30×40	110 60×110	20 20×30	110 60×110	$\frac{1}{11}$	·091	2·31
11¼	20×80 20×40	50× 90 45× 50	20×40 20×60	50× 90 75× 90	$\frac{4}{45}$	·089	2·26
11½	20×60 30×60	30×115 45×115	30×40 30×50	60×115 75×115	$\frac{2}{23}$	·087	2·21
11¾	20×40 20×80	25× 94 50× 94	20×40 20×60	50× 94 75× 94	$\frac{4}{47}$	·085	2·16
12	20 20×30	60 40× 45	20 20×50	120 75× 80	$\frac{1}{12}$	·083	2·11
12¼	20×40 30×40	35× 70 35×105	20×30 20×60	35×105 70×105	$\frac{4}{49}$	·081	2·07
12½	20×80 30×40	50×100 50× 75	20×40 30×40	50×100 75×100	$\frac{2}{25}$	·08	2·03
—	63×30 63×40	60×100 80×100	63×20 63×30	80×100 100×120	—	·079	2·

Threads per inch to be cut.	GUIDE-SCREW, ¼in. PITCH.		GUIDE-SCREW, ⅓in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
$12\frac{3}{4}$	20×80 20×40	60× 85 30× 65	20×40 30×40	60× 65 85× 90	$\frac{4}{51}$	·078	1·99
13	20 40×45	65 65× 90	20×40 20×50	65× 85 65×100	$\frac{1}{13}$	·077	1·95
$13\frac{1}{4}$	20×40 30×40	50× 53 53× 75	20×30 20×40	53× 75 53×100	$\frac{4}{53}$	·075	1·92
$13\frac{1}{2}$	20×60 20×80	45× 90 60× 90	20×40 25×40	60× 90 75× 90	$\frac{2}{27}$	·071	1·88
$13\frac{3}{4}$	20×80 30×80	50×110 75×110	20×40 30×40	50×110 75×110	$\frac{4}{55}$	·071	1·84
14	20 30×40	70 60× 70	20×40 20×50	70× 80 70×100	$\frac{1}{14}$	·071	1·81
$14\frac{1}{2}$	20×40 30×40	50× 58 75× 58	20×30 20×40	58× 75 58×100	$\frac{2}{29}$	·068	1·75
15	20 20×40	75 30×100	20×30 20×45	50× 90 75× 90	$\frac{1}{15}$	·066	1·69
$15\frac{1}{2}$	20×40 30×40	50× 62 62× 75	20×40 20×30	62×100 62× 75	$\frac{2}{31}$	·064	1·64
16	20 20×75	80 60×100	20×25 20×30	50× 80 60× 80	$\frac{1}{16}$	·062	1·58
$16\frac{1}{2}$	20×40 30×40	30×110 45×110	20×40 20×30	60×110 55× 90	$\frac{2}{33}$	·06	1·54
—	63×30 63×45	100× 80 100×120	45×21 63×15	80×100 80×100	—	·059	1·5
17	20 30×40	85 60× 85	20×30 20×45	60× 85 85× 90	$\frac{1}{17}$	·058	1·49

Threads per inch to be cut.	GUIDE-SCREW, ¼in. PITCH.		GUIDE-SCREW, ½in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
$17\frac{1}{2}$	20×40 30×40	50× 70 70× 75	20×30 20×40	70× 75 70×100	$\frac{2}{35}$	·057	1·45
18	20 30×40	90 60× 90	20×30 25×30	60× 90 75× 90	$\frac{1}{18}$	·055	1·41
$18\frac{1}{2}$	20×60 20×80	74× 75 74×100	20×40 20×30	74×100 74× 75	$\frac{2}{37}$	·054	1·37
19	20 30×40	95 60× 95	20×30 20×40	60× 95 80× 95	$\frac{1}{19}$	·053	1·34
$19\frac{1}{2}$	20×40 20×50	60× 65 65× 75	20×30 20×25	65× 90 65× 75	$\frac{2}{39}$	·051	1·3
20	20 20×40	100 50× 80	20×30 20×35	60×100 70×100	$\frac{1}{20}$	·05	1·27
$20\frac{1}{2}$	20×40 20×60	50× 82 75× 82	20×30 20×40	75× 82 82×100	$\frac{2}{41}$	·049	1·24
21	20×40 30×40	60× 70 70× 90	20×25 20×30	70× 75 70× 90	$\frac{1}{21}$	·047	1·21
$21\frac{1}{2}$	30×40 20×40	75× 86 50× 86	20×40 20×30	86×100 75× 86	$\frac{2}{43}$	·046	1·18
22	20 30×40	110 60×110	20×30 20×40	60×110 80×110	$\frac{1}{22}$	·045	1·15
$22\frac{1}{2}$	20×40 30×40	50× 90 75× 90	20×30 20×35	75× 90 75×105	$\frac{2}{45}$	·044	1·13
23	20 30×40	115 60×115	20×25 20×30	50×115 60×115	$\frac{1}{23}$	·043	1·104
$23\frac{1}{2}$	20×32 32×40	40× 94 80× 94	20×34 24×25	60× 94 75× 94	$\frac{2}{47}$	·042	1·082

Threads per inch to be cut.	GUIDE-SCREW, ¼in. PITCH.		GUIDE-SCREW, ½in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
24	20 20×40	120 60× 80	20×25 20×25	75× 80 60×100	$\frac{1}{24}$	·041	1·058
24½	20×40 24×30	70× 70 70× 63	20×20 20×24	70× 70 70× 84	$\frac{2}{49}$	·040	1·037
25	20×30 20×60	50× 75 75×100	20×30 20×20	75×100 50×100	$\frac{1}{25}$	·04	1·016
—	63×20 35×45	80×100 100×100	21×30 21×45	80×100 100×120	—	·039	1·
26	20×30 25×40	60× 65 65×100	20×25 20×30	65×100 65×120	$\frac{1}{26}$	·038	·977
27	20×40 25×40	60× 90 75× 90	20×40 20×25	90×120 75× 90	$\frac{1}{27}$	·037	·941
28	20×40 25×40	70× 80 70×100	20×25 20×30	70×100 70×120	$\frac{1}{28}$	·035	·907
30	20×40 20×50	60×100 75×100	20×40 20×25	100×120 75×100	$\frac{1}{30}$	·033	·846
32	20×30 25×40	60× 80 80×100	20×25 20×30	80×100 80×120	$\frac{1}{32}$	·031	·794
34	20×30 20×45	60× 85 85× 90	20×25 20×30	85×100 85×120	$\frac{1}{34}$	·029	·747
35	20×30 20×40	70× 75 70×100	20×30 —	100×105 —	$\frac{1}{35}$	·028	·726
36	20×30 25×40	60× 90 90×100	20×25 20×30	90×100 90×120	$\frac{1}{36}$	·027	·705
38	20×30 20×40	60× 95 80× 95	20×25 20×30	95×100 95×120	$\frac{1}{38}$	·026	·668

Threads per inch to be cut.	GUIDE-SCREW, ¼-in. PITCH.		GUIDE-SCREW, ½in. PITCH.		PITCH OF SCREW TO BE CUT.		
	Drivers.	Driven.	Drivers.	Driven.	Fractions of an inch.	Decimals of an inch.	Millimètres.
40	20×30 20×40	75× 80 80×100	20×30 20×25	100×120 100×100	$\frac{1}{40}$	·025	·635
42	20×25 20×30	70× 75 70× 90	20×20 20×21	70×120 63×140	$\frac{1}{42}$	·024	·604
44	20×30 20×40	60×110 90×110	20×30 20×25	110×120 100×110	$\frac{1}{44}$	·023	·577
45	20×30 20×40	75× 90 90×100	20×20 20×25	90×100 90×125	$\frac{1}{45}$	·022	·564
46	20×50 20×40	100×115 80×115	20×25 20×30	100×115 115×120	$\frac{1}{46}$	·022	·552
50	20×30 20×40	75×100 100×100	20×20 20×24	100×100 100×120	$\frac{1}{50}$	·02	·508
55	20×30 20×40	75×110 100×110	20×25 —	110×125 —	$\frac{1}{55}$	·018	·462
60	20×25 20×30	50×100 75×120	20×20 20×30	120×100 120×150	$\frac{1}{60}$	·017	·423
65	20×30 —	75×130 —	20×25 —	125×130 —	$\frac{1}{65}$	·015	·391
70	20×30 20×20	100×105 70×100	15×20 20×30	105×125 125×140	$\frac{1}{70}$	·014	·363
80	20×20 20×25	80×100 100×100	15×15 15×20	75×150 100×150	$\frac{1}{80}$	·012	·317
90	20×30 —	90×150 —	20×15 —	90×150 —	$\frac{1}{90}$	·011	·282
100	20×15 —	75×100 —	20×15 —	100×150 —	$\frac{1}{100}$	·01	·254

CHAPTER XI.

SCREW OR SPIRAL AND WORM-WHEELS.

IT is well to first distinguish between these two forms of wheel teeth. The teeth of an ordinary spur-wheel are cut straight across its circumference in a line with its axis. When cut in a helical line, the teeth are called twisted, if the wheels are intended for gearing together on parallel axles; wheels of this kind are very smooth in their action. When the teeth are cut helically, and intended to gear together at an angle, the wheels are called screw- or spiral-wheels. When a wheel has its teeth cut to gear with a screw, placed at right angles to its axis or nearly so, it is called a worm-wheel; the screw is always the driver, and is called a tangent screw.

Screw- or spiral-wheels and worm-wheels can be made on the screw-cutting lathe, as they really form only multiple threads, the number of which corresponds with the number of teeth in the wheel. The pitch being very high, it is often, in fact generally, necessary to use for the cutting tool a revolving toothed wheel or a kind of slot-drill, in place of the ordinary screw-cutting tool in the slide-rest.

In twisted wheels the pitch surfaces roll upon each other exactly as happens with spur-wheels, the axes being parallel. In screw-wheels there is an end movement, that is, the sides of the teeth slide upon each other, the axes not being parallel. In screw-wheels the action is similar to that of a screw and nut, one wheel driving another by the end movement of its tooth face. In the case of a worm-wheel and tangent screw

this is readily seen, when the axes are at right angles, and the circular motion of the wheel may then be said to be entirely due to the end motion of the screw-thread. In changing the relative position of the axes from that of a right angle, though still screw-wheels, the action will not be so clearly distinguished as the axes approach nearer to parallelism.

The action of spiral-wheels is generally very smooth and noiseless. This makes them especially suited for some kinds of quick-running machinery, and, as already noted, they can be used for driving shafts at an angle with each other. The surface contact of spiral-wheels when at right angles is not great, and for heavy work it might wear too quickly. Spiral-wheels also have end thrusts, but of course only the same as in a worm-wheel and tangent screw having the same tooth angle. They generally have considerably less tooth angle, and therefore less end thrust.

The angle which the tooth's sides makes with the axis of the wheel is called the angle of the spiral. When two wheels have both either right-handed spirals or both left-handed spirals, then the angle made by their axles will be equal to the sum of the angles of their spirals. When two wheels have their spirals in reverse directions, then the angle made by their axles will be equal to the difference of their spiral angles. Then when both spirals are right-handed, and the angle of each is 45deg., their sum is 90deg., and the axles will be at right angles. But if one is right-handed and the other left-handed, and both the same angle, the difference will be nil, and the axles will be parallel. When the distance between the centres of two shafts, required to be geared together, is a varying one, spiral gears allow a greater range than spur-wheels, and this is sometimes useful to know.

Equal screw gears are somewhat extensively used in some kinds of machinery for changing the direction of motion to an angle of 90deg. without changing its speed. It is obvious that such gears can be made upon the screw-cutting lathe, because the teeth are portions of spirals, and are,

in fact, screw-threads. To make a pair of screw-wheels of equal diameter, a blank is prepared long enough to make the two side by side and with sufficient material for parting them, after the teeth are cut. The teeth are then formed by cutting a multiple screw, the threads of which are equal to the number of teeth required in the wheels. The pitch of the thread must be equal to the circumference of the wheel on its pitch circle, when the wheels are intended to work at right angles. To calculate the change wheels required to cut this pitch, it is only necessary to proceed by the methods explained in connection with simple screw-cutting, as the principles are the same.

In cutting tangent screws to fit and drive worm-wheels cut to diametrical gauge, some special consideration is necessary in calculating the change wheels required to cut a thread to exactly correspond with the wheel teeth. First, the term "diametrical gauge," as applied to wheels, must be clearly understood. It means the number of teeth in each inch of diameter measured on the pitch circle of the wheel. Thus, 12-gauge means 12 teeth per inch diameter, and the gauge number always tells the number of teeth in a wheel 1in. in diameter. Circular pitch is a different measure, and is the distance from the centre of one tooth to the centre of the next, measured on the pitch circle. The two measures may be converted by the following formulæ:

$$\text{Diametrical Gauge} = \frac{\pi}{\text{Circular Pitch}}$$

and

$$\text{Circular Pitch} = \frac{\pi}{\text{Diametrical Pitch}}.$$

Diametrical gauge has long been recognised as the standard measurement for spur-wheels, brace-wheels, &c., and it is equally good for worm-wheels, though the circular pitch is general with these. The principal reason for this is that lathes are ordinarily arranged for cutting definite numbers of threads per inch, and the tangent screw having been cut

on this principle, a worm-wheel to fit it must have a definite number of teeth per circular inch—that is a wheel of circular pitch. If a worm-wheel of diametrical gauge were to be used, the tangent screw to fit it would require to have a definite number of teeth per π inches. This only means that if we take a wheel of standard gauge, we must cut a screw of fractional pitch to fit it; whilst, on the other hand, if we take a screw of standard pitch, we must cut a wheel of fractional gauge to fit it. Although the latter is the more frequent method, yet the former is often much less troublesome, and less costly.

To equip a lathe once for all, so that it can at any time cut a screw to any pitch required to fit the teeth of a wheel made to diametrical gauge, it is only necessary to arrange a pair of change wheels in the ratio of π. On page 126 will be found some explanations as to this ratio, and the various numbers there are used to approximate it.

We may be quite satisfied with a ratio of 22 : 7 for the compound wheels of any screw-cutting machine, because this gives a ratio much nearer exact, mathematically, than the product of a screw-cutting lathe is usually found to be mechanically. In fact, the difference between the thread-rate actually cut with this combination and the theoretical rate will be less than ·005 of an inch in a foot—that is, less than five-thousandths of an inch in one foot. From this it is apparent that the thread we cut with wheels in the proportion of 22 : 7 differs from the calculated thread by an amount less than the error frequently found to occur in good work, and even in ordinary leading screws. Errors of expansion, and inaccuracies of the guide-screw, would be a more fruitful source of trouble than the difference between $\frac{7}{22}$ and π.

As an example, suppose a tangent screw is required to fit a wheel of 4-gauge; that is, having four teeth per inch of diameter—it matters not for the purpose of this example how large or how small the wheel may be. Suppose the lathe guide-screw has two threads per inch, and a change wheel having 40 teeth is on the mandrel, and one having 80 teeth on the guide-screw, this gives the train for cutting

four threads per inch, any wheel being used to connect the two named. Now, suppose we put two wheels in the ratio of $\frac{7}{22}$ to connect these, say a wheel having 35 teeth and one having 110 teeth, this will give the ratio of π to the wheel teeth of 4-gauge. The thread cut by this arrangement of change wheels will be:

$$\frac{40 \times 110}{2 \times 80 \times 35} = \frac{11}{14};$$

that is to say, the work will rotate 11 times whilst the guide-screw rotates 14 times, and this latter being half in pitch it follows that 11 turns of the work will occur whilst the travel of the tool is 7in., consequently the thread produced will be $\frac{7}{11}$ of an inch pitch, or decimally ·7857142857.

The circular pitch of the 4-gauge wheel is $\frac{\pi}{4}$, see rule previously given (page 152). And working this out to ten places of decimals, $\frac{\pi}{4} = \frac{3{\cdot}1415926539}{4} = {\cdot}7853981635.$

From these two calculations we can easily see the amounts by which the pitch actually produced and the theoretical pitch differ. Subtracting the lesser from the greater, we get:

$$\begin{array}{r} {\cdot}7857142857 \\ -{\cdot}7853981635 \\ \hline {\cdot}0003161222 \end{array}$$

thus showing that the pitch of the thread produced is a very small fraction more than $\frac{3}{10000}$ of an inch coarser than the theoretical pitch, a quantity practically inappreciable.

Tangent screws gear with only a very few teeth of the wheel they drive, and consequently the effect of a small error does not become magnified by accumulating as an ordinary screw would.

From the foregoing the practicability of cutting tangent screws or worms sufficiently accurate to gear with wheels having their teeth cut to diametrical gauge is amply shown.

An advantage of adopting this plan may be mentioned. The odd diameters common to worm-wheels would no longer prevail; this would save much calculation in designing, drawing, and making. The distances between the axes of worm-wheels and tangent screws would be no longer measured by odd sixty-fourths or hundredths of an inch, the distance would be expressed by the number of the wheel-gauge and the diameter of the screw on its pitch line; the two added together and halved give the distance between working centres.

CHAPTER XII.

MACHINES FOR SCREW-MAKING.

THE machine shown at Fig. 65 is the kind originated some decades ago in France, and it is still in use. Very many of the machine-made screws—of the smaller sizes especially—now sold are produced on the old-fashioned French

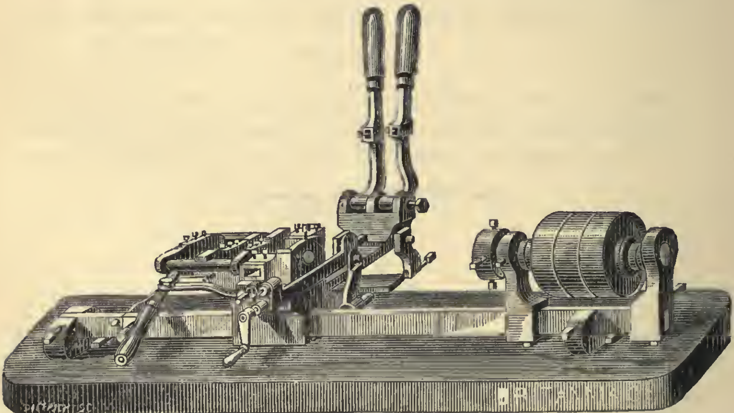


FIG. 65. FRENCH SCREW-MAKING MACHINE.

machines of the type illustrated. These machines are made with a wrought-iron bed, and have a series of cutters arranged on the apparatus shown facing the mandrel. These cutters are successively brought into action by manipulating the

different levers and winch handles. Stop-screws are fitted, against which the shifting parts butt. Commonly about six different cutters can be used on this machine, and this number affords ample variety; indeed, more often only three or four are actually used. The mandrel is tubular to admit long rods, and has two loose pulleys and one fast. This is to allow the use of two driving-belts, one open and one

FIG. 66. HEXAGONAL BAR FOR MAKING A BOLT.

crossed by which the direction of rotation can be changed at will.

The construction of this type of screw-making machine is such that it requires considerable attention from the operator, and is in no way automatic. The work produced upon it takes much longer than with the modern machines shown on later pages, and is not comparable in quality either.

The accompanying seven figures (66 to 72) show the usual

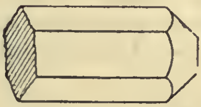


FIG. 67. THE HEXAGONAL BAR POINTED.

stages in making a bolt on a machine or with a turret-rest. Fig. 66 shows a piece of hexagonal bar metal the size of the head of the intended bolt. This is fixed in a chuck leaving just enough material projecting to form the complete bolt, and allow for cutting off. The first operation on the rough material is to point the end as shown by Fig. 67. This reduces the projecting piece to an exact length, and leaves a portion turned true to assist the next tool in starting fair.

Fig. 68 shows the bolt as roughed down by the first turning tool, which removes nearly all the superfluous material. A carefully-set sizing-tool follows, and reduces the shank of the bolt to exact size, and cuts the shoulder square under the

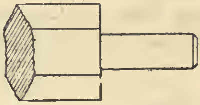


FIG. 68. THE BOLT TURNED TO APPROXIMATE SIZE.

head as shown by Fig. 69. By employing two cutters for this process, one to remove the bulk of the material and leave only a slight cut for the finishing tool, this latter is capable

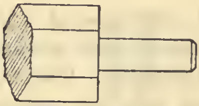


FIG 69. THE BOLT TURNED TO EXACT SIZE.

of sizing a very large quantity of bolts without requiring to be re-ground. The next operation is shown at Fig. 70. This consists in cutting the thread, a solid die being generally

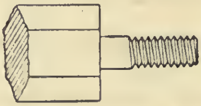


FIG. 70. THE THREAD CUT.

employed for this purpose. After cutting the thread, the bolt has its point chamfered as shown at Fig. 71, thus preventing a ragged thread, and making the bolt enter better when being screwed into a hole. Fig. 72 shows the final

operation of parting off the complete bolt; a narrow tool is used, and the bolt falls off, leaving the end of the hexagon bar flat, except perhaps a small "tit" at its centre. The bar is next drawn out of the chuck the required amount, as shown by a stop, and then presents the appearance of Fig. 66. So the whole series of operations are gone through continuously, the only break occurring when the bar is used

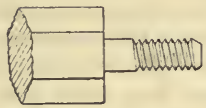


FIG. 71. THE POINT CHAMFERED.

up and another one takes its place, and when the tools require grinding and the machine is stopped for this to be done.

The common wood screws, by which is meant those used by carpenters, joiners, and other wood workers in fixing the parts of wooden structures together, are now made in this country almost exclusively by one firm. An enormous factory containing the most perfect machinery, equal to an output

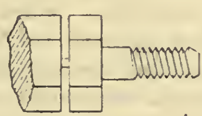


FIG. 72. THE COMPLETE BOLT CUT OFF FROM THE BAR.

of millions of screws daily, and backed with any amount of capital, furnishes practically all the wood screws used. Though this treatise does not profess to deal with this branch of screw-making, yet some particulars of the methods employed will be interesting.

In making common wood screws the wire is first cut into lengths each sufficient to form one screw. One end of each

blank is next upset to form the head, this being done cold. Every diameter of screw, and also every length of screw, require its particular blank made precisely to the requisite size. These rough blanks are placed in a circular revolving tray, from which they are automatically collected and fed into a machine, which turns the head and cuts the nick in it. A forked arm continually dips into the blanks on the tray, and lifts a number by their heads. These the fork delivers in an inclined groove, where they hang suspended by their heads and travel to a gripper, which seizes the foremost blank and rotates it rapidly whilst a cutter approaches and trims the head. Another gripper now seizes that blank, and conveys it opposite a small circular saw, which cuts the nick in the head. The burr from the saw is removed, and the blanks are all examined and defective ones thrown out.

The threading is done next, and the blanks are fed automatically into this machine in which a spindle holds the blank by its head and revolves it rapidly whilst a tool shapes the point. A screwing-tool having one point only next comes into operation. The blank turns in the reverse direction to the usual, so that the cutter commences to act near the middle of the shank and finishes its cut at the point. The travel necessary to make the thread-rate is given to the whole spindle which rotates the screw blank, the tool not having any motion lengthwise. When the point is reached the tool falls back from cut and the spindle at once jumps back into position to commence its traverse. The tool is again brought up to cut, and another shaving is taken out of the groove. In each trip that is taken, the tool is fed into cut slightly and several trips are taken to cut the thread on each screw. Five or six is a usual number of cuts, but large screws require a dozen and even more trips to fully cut out the thread. The screws are now practically finished, though they go through various processes of riddling, sorting, and examining before being finally packed for sale. The large screws are counted when put into packets, the smaller ones being made up by weight.

Endeavours have been made to produce screws by im-

pressing the groove between the thread instead of cutting it. This has been done experimentally for many years, and now a certain amount of success has been achieved commercially. The advantages of rolling screw-threads as compared with cutting them are very important in some respects. Material is not wasted in shavings, and the blanks are considerably shorter than the required screws, the rolling process elongating them. The thread can be raised by rolling, so that it becomes larger than the blank. The resulting screw has greater tensile strength than one that has been cut.

Fig. 73 shows a method of rolling the thread on wood screws. Two discs, having their edges grooved concentrically to correspond with the required thread, are mounted (as shown) with the grooves placed angularly to suit the rake of the

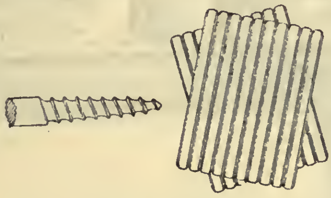


FIG. 73. ROLLING THE THREAD ON WOOD SCREWS.

thread to be rolled. The screw-blank is impressed with the thread when passed between them. The illustration is intended only to show the principle on which these disc rollers work, and all details of the machine by which they are actuated are purposely omitted.

Another method of rolling screw-threads is by flat-faced dies. A pair of these, having inclined grooves, are made to slide parallel, but in opposite directions; the screw-blank placed between these dies is rolled and impressed with the thread by a kind of swaging process. Wood screws made by this plan are now manufactured, and they differ in many important points from the cut wood screws now in general use.

Fig. 74 shows a chasing-lathe fitted with automatic feed for the turret-slide. The illustration shows a machine, 7in. centre, with bed 4ft. 9in. long. The turret is 6$\frac{3}{4}$in. diameter, with six holes 1in. diameter. This engraving is inserted specially to show the chasing apparatus, modifications of which are often used on lathes for brass-finishers. A parallel rod is fitted in bearings parallel with the mandrel. The right-hand end of this rod is fitted to carry screw-chasing tools, which are attached to it by any simple fixing arrangement. At the left-

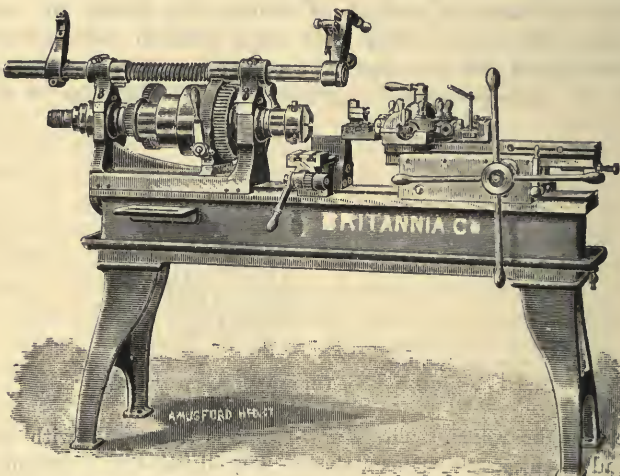


FIG. 74. CHASING-LATHE.

hand end of the rod an arm is fitted, to which a piece of hard wood or of soft metal is fixed. This forming a comb which engages with a threaded sleeve on the tail end of the mandrel. The sleeves are easily changed, and one of suitable pitch is used, according to the work to be screwed.

The following method of threading screws of all kinds is perhaps the quickest of all. Two equal-sized flat steel discs, usually about 5in. diameter, have a well-defined counterpart

M 2

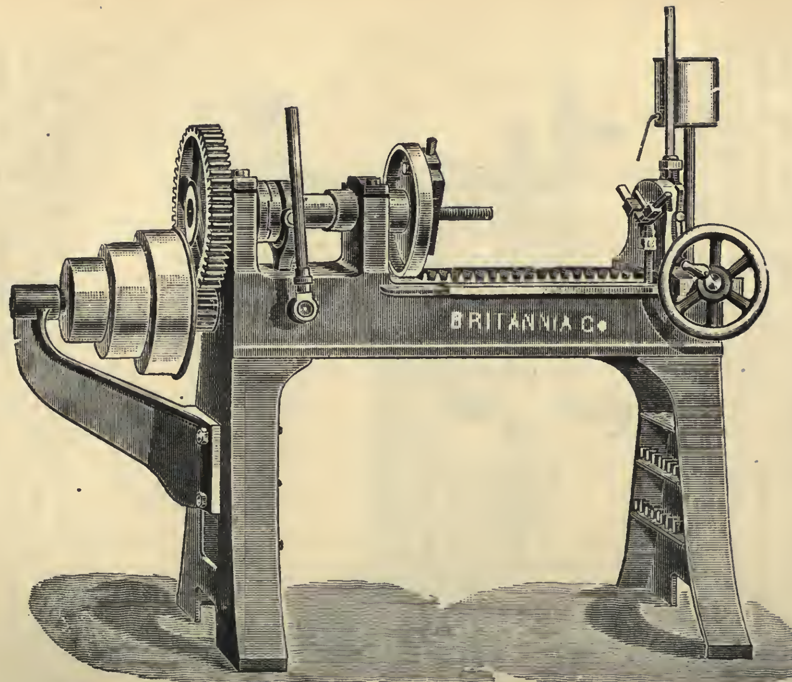


Fig. 75. Patent Screwing-Machine.

of the required thread cut on their faces spirally, starting from the edge, and extending towards the centre, at least as far as the length of the intended screw. These two steel discs take the place of dies, &c.; they are, of course, hardened and tempered. They are fitted in a machine to run in opposite directions and facing each other. When idle, they are sufficiently far apart to allow of the screw-blank being introduced between them. When the rod metal is inserted, as far as the thread is intended, the discs are brought together so as to leave only the diameter of the finished screw between them. The rod is at once caused to rotate by the action of the discs, and the thread is impressed, the spiral on the discs causing the newly-made screw to travel outwards. When the discs have rotated as many times as there are turns on the screw-thread being formed, this will be free of the discs, and is finished so far as concerns the threading. Threads rolled in this way are much stronger in resisting stripping than cut threads. Also this process enables threads to be rolled larger in diameter than the blank rods; quite an important consideration when large quantities of bolts are in question, as the weight of material saved in bolts of given strength is a large percentage.

The new patent screwing machines (McIlquham's Patent), shown at Fig. 75, are constructed on improved and very simple principles, greatly advantageous to users in point of economy, both in working and maintaining in repair. The headstock is constructed with a hollow spindle to take rods or tubes of any length, and with a self-centreing die-chuck for gripping rods, tubes, or bolt-heads. A clutch and lever enables the machine to be started and stopped instantly and independently of the counter-shaft. The spindle is driven by a 3-speed cone pulley and powerful gearing. The bed is machine planed, of trough section to catch the soap and water used in screwing, and is fitted with a tap to draw off. Fitted to the bed is a sliding saddle, moved by racks and pinions, and a hand-wheel, which carries the screwing head. This is fitted with three tool-boxes, carrying tools similar to ordinary chasers, and so constructed as to be held firmly in position

by one set-screw to each. These are closed and opened by lever and eccentric cam, and the top face of the screwing-head is graduated and fitted with a stop to adjust the depth of cut. The BRITANNIA COMPANY, Colchester, manufacture these patented machines.

The important feature of this screwing-head (Fig. 76) is the simplicity of the dies, which are merely pieces of steel cut off a bar, put into the tool-holder and secured by set-screws. In

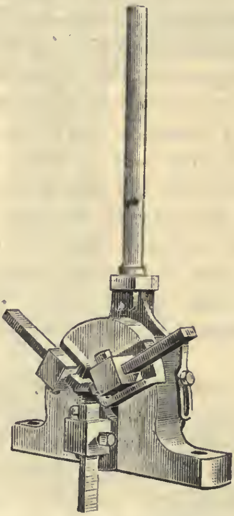


FIG. 76. PATENT SCREWING-HEAD.

this machine they can then be cut up by the master-tap and hardened and finished ready for use; no expensive fitting for length or in any other respect is needed; but each die is fixed as an ordinary turning tool is put in the slide-rest of a lathe.

The advantages of this machine may be thus summarised: The thread is completed at a single cut. The screwing dies are as easily sharpened by grinding the face as with ordinary lathe-chasers, and hence do ten or twelve times the work of

many complicated systems in the market. The screwing dies, when at last fairly worn out, are cheaply replaced by any ordinary mechanic, by merely cutting pieces from a bar of steel, fixing in their places by set-screws, as an ordinary lathe-tool, and cutting the thread in his own machine by the master-tap supplied. The method of holding the dies is so arranged that the strain comes on the rest or holder, instead of upon the dies, which thus endure much more work. The arrangement of the screwing head and dies enables the cutting edges to be plainly seen, and these are clear for work and cannot get choked by cuttings. The clutch arrangement enables the machine to be stopped instantly, in case of accident or necessity. The whole is so simple that there is nothing to get out of order by ordinary fair use, and if breakage occurs by any mishap, parts can be easily replaced.

Each machine is sent out complete with master-taps and dies for $\frac{1}{2}$in., $\frac{5}{8}$in., $\frac{3}{4}$in., $\frac{7}{8}$in., and 1in. threads, reversing over-head motion, standards fitted with shelves for dies and taps, screw-keys, &c., &c.

Dimensions: Bed, 4ft. long; 10in. on face; 6in. deep; cone pulley, 3 speeds, 3in. wide; largest, 12in. diameter; gearing, $\frac{3}{4}$in. pitch, 2in. face; spur-wheel $12\frac{1}{2}$in. diameter and pinion $4\frac{1}{2}$in.; spindle bored with $1\frac{3}{4}$in. hole; approximate weight, 8cwt. Price complete, £35. The patented screwing head can be fixed to existing machines, or to the saddles of ordinary lathes.

Fig. 77 shows a screw-making machine adapted for making from rods of steel, iron, brass, &c., screws and studs, from $\frac{1}{2}$in. to $\frac{3}{4}$in. diameter, and with care much smaller ones may be made. It is also adapted for turning the ends and threading gas- and water-tubing, &c. All screw-making machines have hollow mandrels bored through to allow the rod or wire from which the screws are made to pass inside; they are fitted with split chucks suited to grip the various sizes of wire used; this is straightened, the size being selected to gauge just a trifle more than the diameter of the heads of the screws to be made.

In many machines, besides the usual driving pulley, the

mandrel has fixed on it another, over which a band passes within easy reach of the operator, who, by a pull, reverses the motion of the mandrel when the thread has to be cut on the blank. Oftentimes the usual motion of the lathe is the

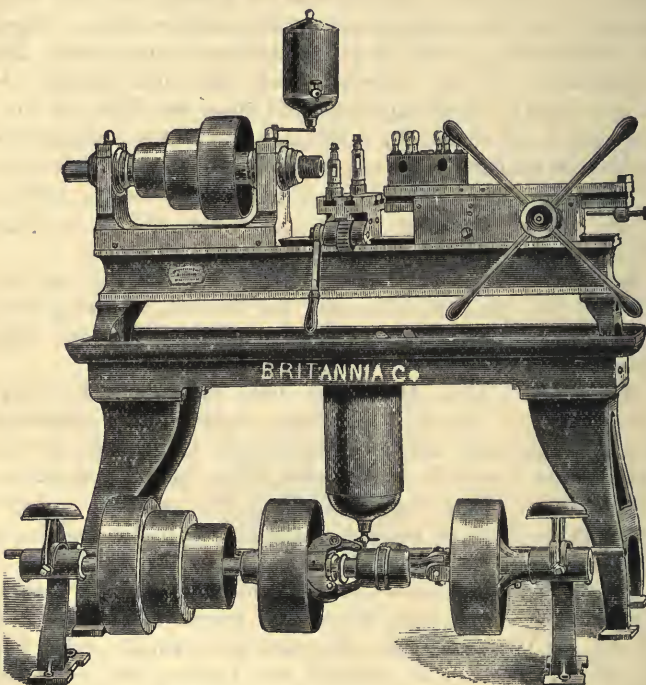


FIG. 77. SCREW-MAKING MACHINE.

reverse to the ordinary way—that is to say, the work runs *from* the operator—and it is by a pull with the hand that the workman rotates the lathe in the reverse direction for running the blank screw into the die; he is thereby enabled to feel, with great accuracy and precision, the moment when the head

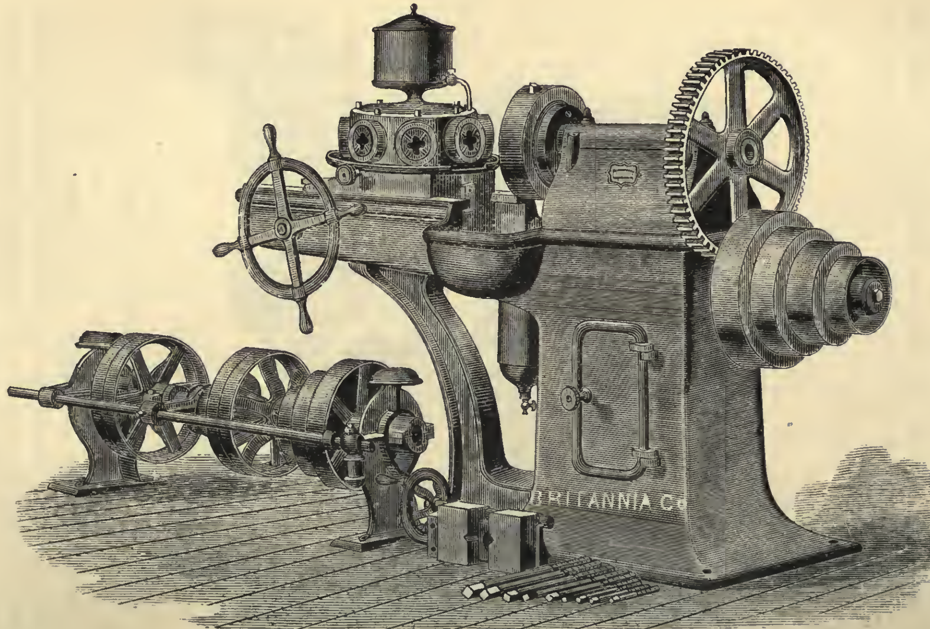


Fig. 78. Bolt-threader with Turret-head.

of the screw comes to the shoulder, and check the motion in time to prevent the thread being twisted off. The several operations, tedious to describe, are performed with such rapidity in practice that it necessitates the utmost vigilance on the part of an onlooker to detect the different changes, and declare exactly when a screw is begun and when completed.

The machine shown at Fig. 78 is intended for threading bolts, and it has seven dies in the turret-head giving the choice of seven different sizes on the one machine, without requiring any change of dies. The turret-head is merely rotated to the position required to bring the dies wanted opposite the mandrel. This facility renders a machine of this kind particularly serviceable in any place where the quantities of bolts to be threaded is small and the variety calls for frequent changes in the dies. The machine illustrated is contrived so that the chips and oil are caught in the bed; a strainer keeps back the chips and yet allows the oil to drain into the receiver from which it is drawn to be again used.

The spiral twist on augers exemplify a peculiar kind of screw-thread. These auger twists are made in a twisting-machine, which takes the flat bar of metal and twists it roughly into spiral form. This is next put through rollers called crimpers, which regulate the pitch of the twist and make it uniform. The twisted bar is then straightened, and the grooves roughly ground by means of a pair of wheels. The cutting parts and the points are then filed to shape, and the augers are hardened and tempered. Finally the spiral twist is polished, and the tools are finished for sale.

The automatic watch-screw machine (illustrated by Fig. 79) is, as its name indicates, especially intended for making the screws used in watchwork, though it is also equally suited for making any small screws and other turned things of a similar size and kind. The motions are wholly automatic; they are controlled by a series of cams on a single shaft running in the lower part of the frame lengthwise of the machine. The motion of this shaft is fast or slow according

to whether the tools are being brought into position to do work or are actually cutting at the time. The fast and slow motions are varied to meet the requirements of different work by means of movable stops. The tools are held in spindles, two, three, or four of these being fitted to the turret-head, which revolves in a vertical plane, the axis of which is parallel to these spindles and also to the main spindle in the fixed head. Each spindle is fed in and out of cut when in the proper position to do its work.

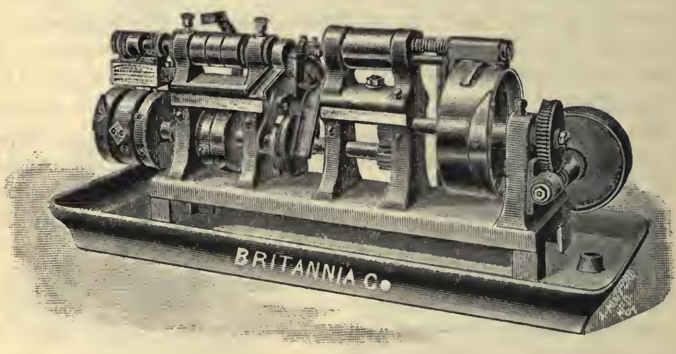


FIG. 79. AUTOMATIC WATCH-SCREW MACHINE.

A machine made especially for screwing tubing as used for gas and water fittings is shown at Fig. 80. This machine has a strong mandrel which can be rotated by means of the long winch handle shown on the right. This handle acts through strong gearing to give sufficient power to enable the machine to be actuated by hand. The end of this mandrel has a square recess in which a solid die is placed, and various sizes of threads can be screwed by changing this die for another of the size required. The tube to be screwed is inserted in the strong gripping arrangement on the left and secured by turning the lever handle on the top. This brings the jaws together and firmly grasps the tube so that

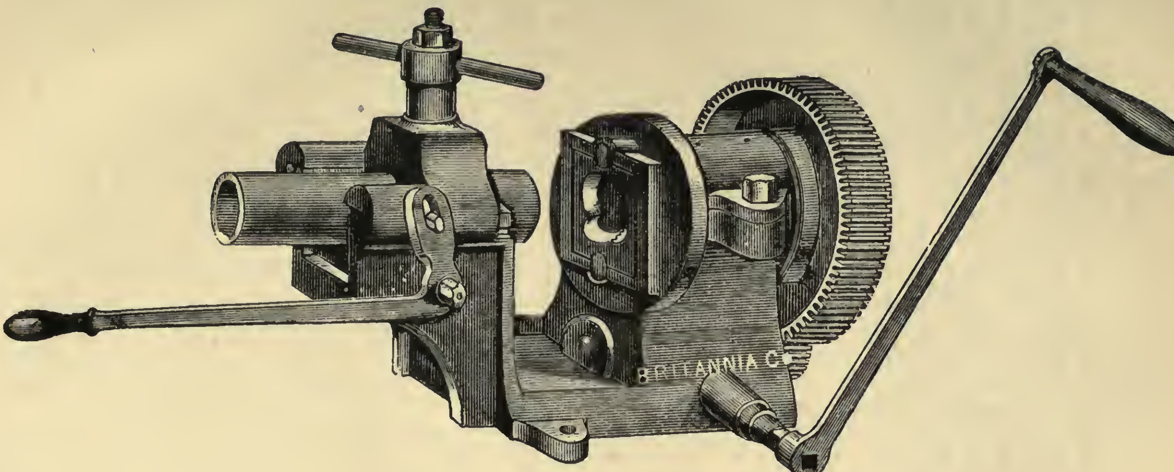


Fig. 80. Tube-screwing Machine.

it cannot turn round through the action of the screwing die. The entire gripping arrangement is, however, capable of being slided along to and from the mandrel by lifting and depressing the handle on the left. It is by this means that the tube is forced into the die at the commencement of the screwing operation, though when the die has once fairly taken hold of the tube it draws its own cut and further forcing by means of the handle is not requisite.

CHAPTER XIII.

VARIOUS TABLES OF SCREWS, &c.

WHITWORTH'S STANDARD THREADS.

(For Particulars of Thread Form see page 24.)

Outside Diam.	Threads per in.	Diam. Bottom. Decimals.	Size for Tapping.	Pitch in Decimals.	Pitch in Millimètres.
$\frac{1}{32}$	150	·0293	—	·0066	·169
$\frac{1}{16}$	60	·0413	$\frac{3}{64}$	·0166	·4233
$\frac{3}{32}$	48	·0671	$\frac{5}{64}$	·0208	·529
$\frac{1}{8}$	40	·093	$\frac{3}{32}$	·025	·635
$\frac{5}{32}$	32	·112	$\frac{1}{8}$	·0312	·793
$\frac{3}{16}$	24	·134	$\frac{9}{64}$	·0416	1·06
$\frac{7}{32}$	24	·165	$\frac{11}{64}$	·0416	1·06
$\frac{1}{4}$	20	·186	$\frac{3}{16}$	·05	1·27
$\frac{5}{16}$	18	·241	$\frac{1}{4}$	·0555	1·41
$\frac{3}{8}$	16	·295	$\frac{19}{64}$	·0625	1·587
$\frac{7}{16}$	14	·346	$\frac{23}{64}$	·0714	1·814
$\frac{1}{2}$	12	·393	$\frac{13}{32}$	·0833	2·116
$\frac{9}{16}$	12	·455	$\frac{15}{32}$	·0833	2·116
$\frac{5}{8}$	11	·508	$\frac{33}{64}$	·0909	2·39
$\frac{11}{16}$	11	·571	$\frac{37}{64}$	·0909	2·39
$\frac{3}{4}$	10	·622	$\frac{5}{8}$	·1	2·54
$\frac{13}{16}$	10	·684	$\frac{11}{16}$	·1	2·54
$\frac{7}{8}$	9	·732	$\frac{47}{64}$	·111	2·822
$\frac{15}{16}$	9	·795	$\frac{51}{64}$	·111	2·822
1	8	·840	$\frac{27}{32}$	·125	3·175
$1\frac{1}{8}$	7	·942	$\frac{61}{64}$	·1428	3·628
$1\frac{1}{4}$	7	1·067	$1\frac{1}{16}$	·1428	3·628
$1\frac{3}{8}$	6	1·161	$1\frac{11}{64}$	·1666	4·233
$1\frac{1}{2}$	6	1·286	$1\frac{19}{64}$	·1666	4·233
$1\frac{5}{8}$	5	1·368	$1\frac{3}{8}$	·2	5·08

WHITWORTH'S STANDARD THREADS—*Continued.*

Outside Diam.	Threads per in.	Diam. Bottom. Decimals.	Size for Tapping.	Pitch in Decimals.	Pitch in Millimètres.
$1\frac{3}{4}$	5	1·494	$1\frac{1}{2}$	·2	5·08
$1\frac{7}{8}$	$4\frac{1}{2}$	1·59	$1\frac{19}{32}$	·2222	5·644
2	$4\frac{1}{2}$	1·715	$1\frac{23}{32}$	·2222	5·644
$2\frac{1}{8}$	$4\frac{1}{2}$	1·84	$1\frac{27}{32}$	·2222	5·644
$2\frac{1}{4}$	4	1·93	$1\frac{15}{16}$	·25	6·35
$2\frac{3}{8}$	4	2·054	$2\frac{1}{16}$	·25	6·35
$2\frac{1}{2}$	4	2·18	$2\frac{3}{16}$	·25	6·35
$2\frac{5}{8}$	4	2·304	$2\frac{5}{16}$	·25	6·35
$2\frac{3}{4}$	$3\frac{1}{2}$	2·384	$2\frac{13}{32}$	·2857	7·257
$2\frac{7}{8}$	$3\frac{1}{2}$	2·509	$2\frac{33}{64}$	·2857	7·257
3	$3\frac{1}{2}$	2·634	$2\frac{41}{64}$	·2857	7·257
$3\frac{1}{8}$	$3\frac{1}{2}$	2·759	$2\frac{49}{64}$	·2857	7·257
$3\frac{1}{4}$	$3\frac{1}{4}$	2·856	$2\frac{55}{64}$	·3077	7·815
$3\frac{3}{8}$	$3\frac{1}{4}$	2·98	$2\frac{63}{64}$	·3077	7·815
$3\frac{1}{2}$	$3\frac{1}{4}$	3·105	$3\frac{1}{8}$	·3077	7·815
$3\frac{5}{8}$	$3\frac{1}{4}$	3·23	$3\frac{15}{64}$	·3077	7·815
$3\frac{3}{4}$	3	3·32	$3\frac{21}{64}$	·3333	8·466
$3\frac{7}{8}$	3	3·448	$3\frac{29}{64}$	·3333	8·466
4	3	3·573	$3\frac{37}{64}$	·3333	8·466
$4\frac{1}{8}$	3	3·698	$3\frac{43}{64}$	·3333	8·466
$4\frac{1}{4}$	$2\frac{7}{8}$	3·804	$3\frac{13}{16}$	·3478	8·834
$4\frac{3}{8}$	$2\frac{7}{8}$	3·93	$3\frac{15}{16}$	·3478	8·834
$4\frac{1}{2}$	$2\frac{7}{8}$	4·054	$4\frac{1}{16}$	·3478	8·834
$4\frac{5}{8}$	$2\frac{7}{8}$	4·18	$4\frac{3}{16}$	·3478	8·834
$4\frac{3}{4}$	$2\frac{3}{4}$	4·284	$4\frac{19}{64}$	·3636	9·236
$4\frac{7}{8}$	$2\frac{3}{4}$	4·409	$4\frac{27}{64}$	·3636	9·236
5	$2\frac{3}{4}$	4·534	$4\frac{7}{16}$	·3636	9·236
$5\frac{1}{8}$	$2\frac{3}{4}$	4·66	$4\frac{43}{64}$	·3636	9·236
$5\frac{1}{4}$	$2\frac{5}{8}$	4·762	$4\frac{49}{64}$	·3809	9·676
$5\frac{3}{8}$	$2\frac{5}{8}$	4·887	$4\frac{57}{64}$	·3809	9·676
$5\frac{1}{2}$	$2\frac{5}{8}$	5·012	$5\frac{1}{64}$	·3809	9·676
$5\frac{5}{8}$	$2\frac{5}{8}$	5·137	$5\frac{9}{64}$	·3809	9·676
$5\frac{3}{4}$	$2\frac{1}{2}$	5·24	$5\frac{1}{4}$	·4	10·16
$5\frac{7}{8}$	$2\frac{1}{2}$	5·362	$5\frac{3}{8}$	·4	10·16
6	$2\frac{1}{2}$	5·487	$5\frac{1}{2}$	·4	10·16

AMERICAN STANDARD THREADS (SELLERS').

(For Particulars of Thread Form see page 32).

Outside Diameter.	Threads per inch.	Diam. Bottom. Decimals.	Size for Tapping.	Pitch in Decimals.	Pitch in Millimètres.	Width of Flat.
$\frac{1}{4}$	20	·185	$\frac{3}{16}$	·05	1·27	·0062
$\frac{5}{16}$	18	·24	$\frac{1}{4}$	·0555	1·41	·0069
$\frac{3}{8}$	16	·294	$\frac{19}{64}$	·0625	1·587	·0078
$\frac{7}{16}$	14	·345	$\frac{23}{64}$	·0714	1·814	·0089
$\frac{1}{2}$	13	·4	$\frac{13}{32}$	·0769	1·95	·0096
$\frac{9}{16}$	12	·454	$\frac{15}{32}$	·0833	2·116	·0104
$\frac{5}{8}$	11	·506	$\frac{33}{64}$	·0909	2·39	·0114
$\frac{3}{4}$	10	·62	$\frac{5}{8}$	·1	2·54	·0125
$\frac{7}{8}$	9	·731	$\frac{47}{64}$	·1111	2·822	·0139
1	8	·837	$\frac{27}{32}$	·125	3·175	·0156
$1\frac{1}{8}$	7	·939	$\frac{61}{64}$	·1428	3·628	·0178
$1\frac{1}{4}$	7	1·064	$1\frac{5}{64}$	·1428	3·628	·0178
$1\frac{3}{8}$	6	1·158	$1\frac{11}{64}$	·1666	4·233	·0208
$1\frac{1}{2}$	6	1·283	$1\frac{19}{64}$	·1666	4·233	·0208
$1\frac{5}{8}$	$5\frac{1}{2}$	1·389	$1\frac{25}{64}$	·1818	4·62	·0227
$1\frac{3}{4}$	5	1·49	$1\frac{1}{2}$	·2	5·08	·025
$1\frac{7}{8}$	5	1·615	$1\frac{5}{8}$	·2	5·08	·025
2	$4\frac{1}{2}$	1·711	$1\frac{23}{32}$	·2222	5·644	·0277
$2\frac{1}{4}$	$4\frac{1}{2}$	1·961	$1\frac{31}{32}$	·2222	5·644	·0277
$2\frac{1}{2}$	4	2·175	$2\frac{3}{16}$	·25	6·35	·0313
$2\frac{3}{4}$	4	2·425	$2\frac{7}{16}$	·25	6·35	·0313
3	$3\frac{1}{2}$	2·628	$2\frac{41}{64}$	·2857	7·257	·0357
$3\frac{1}{4}$	$3\frac{1}{2}$	2·878	$2\frac{57}{64}$	·2857	7·257	·0357
$3\frac{1}{2}$	$3\frac{1}{4}$	3·1	$3\frac{7}{64}$	·3077	7·815	·0384
$3\frac{3}{4}$	3	3·317	$3\frac{21}{64}$	·3333	8·466	·0416
4	3	3·567	$3\frac{37}{64}$	·3333	8·466	·0416
$4\frac{1}{4}$	$2\frac{7}{8}$	3·798	$3\frac{13}{16}$	·3478	8·834	·0434
$4\frac{1}{2}$	$2\frac{3}{4}$	4·027	$4\frac{1}{32}$	·3636	9·236	·0454
$4\frac{3}{4}$	$2\frac{5}{8}$	4·255	$4\frac{17}{64}$	·3809	9·676	·0478
5	$2\frac{1}{2}$	4·48	$4\frac{31}{64}$	·4	10·16	·05
$5\frac{1}{4}$	$2\frac{1}{2}$	4·73	$4\frac{47}{64}$	·4	10·16	·05
$5\frac{1}{2}$	$2\frac{3}{8}$	4·953	$4\frac{61}{64}$	·421	10·68	·0526
$5\frac{3}{4}$	$2\frac{3}{8}$	5·203	$5\frac{13}{64}$	·421	10·68	·0526
6	$2\frac{1}{4}$	5·423	$5\frac{7}{16}$	·444	11·29	·0555

STANDARD FRENCH THREADS.

Diam. in Mm.	Pitch in Mm.		
	Cail or Railway.	Ducommun.	Armengaud's.
3	—	·50	—
4	—	·75	—
5	1·	·75	1·4
6	1·	1·	—
7	1·25	1·20	—
7·5	—	—	1·6
8	1·25	1·25	—
9	1·50	1·50	—
10	1·50	1·50	1·8
12	1·50	1·75	—
12·5	—	—	2·
14	2·	—	—
15	2·	2·	2·2
17·5	—	—	2·4
18	2·	2·50	—
20	2·	2·50	2·6
22·5	—	—	2·8
23	2·50	3·	—
25	3·	3·	3·
28	3·	3·	—
30	3·	3·50	3·4
32	3·	3·50	—
35	3·50	4·	3·8
38	3·50	4·	—
40	4·	4·	4·2
42	4·	4·50	—
45	4·	4·50	4·6
47	4·50	5·	—
50	4·50	5·	5·
55	—	5·	5·4
60	—	6·	5·8
65	—	6·	6·2
70	—	7·	6·6
75	—	7·	7·
80	—	7·	7·4

SWISS SMALL SCREW GAUGE.

(Adopted by the British Association. See also pages 47, 50, and 61.)

No.	Approximate Dimensions in Decimals of an Inch.			Exact Dimensions in Millimètres.	
	Diam.	Pitch.	Threads per inch.	Diam.	Pitch.
25	·010	·0028	353	0·25	0·072
24	·011	·0031	317	0·29	0·080
23	·013	·0035	285	0·33	0·089
22	·015	·0039	259	0·37	0·098
21	·017	·0043	231	0·42	0·11
20	·019	·0047	212	0·48	0·12
19	·021	·0055	181	0·54	0·14
18	·024	·0059	169	0·62	0·15
17	·027	·0067	149	0·70	0·17
16	·031	·0075	134	0·79	0·19
15	·035	·0083	121	0·90	0·21
14	·039	·0091	110	1·0	0·23
13	·044	·0098	101	1·2	0·25
12	·051	·0110	90·7	1·3	0·28
11	·059	·0122	81·9	1·5	0·31
10	·067	·0138	72·6	1·7	0·35
9	·075	·0154	65·1	1·9	0·39
8	·086	·0169	59·1	2·2	0·43
7	·098	·0189	52·9	2·5	0·48
6	·110	·0209	47·9	2·8	0·53
5	·126	·0232	43·0	3·2	0·59
4	·142	·0260	38·5	3·6	0·66
3	·161	·0287	34·8	4·1	0·73
2	·185	·0319	31·4	4·7	0·81
1	·209	·0354	28·2	5·3	0·90
0	·236	·0394	25·4	6·0	1·00

WHITWORTH'S STANDARD SCREWS FOR WATCH AND INSTRUMENT MAKERS.

(For Particulars of Thread Form see page 24.)

Number denoting thousandths of an inch in diameter.	Threads per inch.	Number denoting thousandths of an inch in diameter.	Threads per inch.
10	400	34	150
11	400	36	150
12	350	38	120
13	350	40	120
14	300	45	120
15	300	50	100
16	300	55	100
17	250	60	100
18	250	65	80
19	250	70	80
20	210	75	80
22	210	80	60
24	210	85	60
26	180	90	60
28	180	95	50
30	180	100	50
32	150		

ORNAMENTAL LATHE-THREADS.

HOLTZAPFFEL'S.

External Diameter.	Letters.	Nos.	Threads per inch.	Pitch of Thread.	Change wheels Guide-Screw = $\frac{1}{4}$in. pitch.
1·000 = 1 in.	A	1	6·58	$\frac{5}{329}$	$\frac{50}{70} \times \frac{40}{47}$
·875 = $\frac{7}{8}$in.	B	2	8·25	$\frac{4}{33}$	$\frac{48}{60} \times \frac{80}{110}$
·750 = $\frac{3}{4}$in.	C	3	9·45	$\frac{20}{189}$	$\frac{50}{90} \times \frac{80}{105}$
·625 = $\frac{5}{8}$in.	DD				
·560	D	4	13·09	$\frac{100}{1309}$	$\frac{20}{70} \times \frac{100}{55} \times \frac{50}{85}$
·500 = $\frac{1}{2}$in.	E				
·450	F	5	16·5	$\frac{2}{33}$	$\frac{40}{110} \times \frac{80}{120}$
·410	G	6	19·89	$\frac{100}{1989}$	$\frac{20}{65} \times \frac{50}{85} \times \frac{100}{90}$
·360	H				
		7	22·1	$\frac{10}{221}$	$\frac{25}{65} \times \frac{40}{85}$
·330	I				
·290	J	8	25·65	$\frac{20}{513}$	$\frac{20}{95} \times \frac{100}{135}$
·250 = $\frac{1}{4}$in.	K				
·210	M	9	28·9	$\frac{25}{722}$	$\frac{20}{85} \times \frac{50}{85}$
·240	L				
·200 = $\frac{1}{5}$in.	N	10	36·1	$\frac{10}{361}$	$\frac{25}{95} \times \frac{40}{95}$
·180	P				
·190	O	11	39·9	$\frac{10}{399}$	$\frac{25}{95} \times \frac{40}{105}$
·162	Q				
·150	R				
·135	S	12	55·	$\frac{1}{55}$	$\frac{20}{100} \times \frac{40}{110}$
·120	T				
·100 = $\frac{1}{10}$in.	U				

WHITWORTH'S STANDARD TUBE THREADS FOR GAS AND WATER PIPES.

Internal Diameter of Pipe.	External Diameter of Pipe.	Diameter at Bottom of Thread.	Number of Threads per inch.
$\frac{1}{8}$	·382	·336	28
$\frac{1}{4}$	·518	·451	19
$\frac{3}{8}$	·656	·589	19
$\frac{1}{2}$	·826	·734	14
$\frac{5}{8}$	·902	·811	14
$\frac{3}{4}$	1·04	·949	14
$\frac{7}{8}$	1·189	1·097	14
1	1·309	1·192	11
$1\frac{1}{8}$	1·492	1·375	11
$1\frac{1}{4}$	1·65	1·533	11
$1\frac{3}{8}$	1·745	1·628	11
$1\frac{1}{2}$	1·882	1·705	11
$1\frac{5}{8}$	2·022	1·965	11
$1\frac{3}{4}$	2·16	2·042	11
$1\frac{7}{8}$	2·245	2·128	11
2	2·347	2·23	11
$2\frac{1}{8}$	2·467	2·351	11
$2\frac{1}{4}$	2·587	2·47	11
$2\frac{3}{8}$	2·794	2·678	11
$2\frac{1}{2}$	3·	2·882	11
$2\frac{5}{8}$	3·124	3·009	11
$2\frac{3}{4}$	3·247	3·13	11
$2\frac{7}{8}$	3·367	3·251	11
3	3·485	3·368	11
$3\frac{1}{4}$	3·698	3·581	11
$3\frac{1}{2}$	3·912	3·795	11
$3\frac{3}{4}$	4·125	4·008	11
4	4·340	4·223	11

WHITWORTH'S STANDARD TAPS.

Outside Diameter.	Full length.	Length of Screw part.	Length of Square.	Size of Square.	Diameter at Bottom of Thread.	Threads per inch.
$\frac{1}{16}$	$1\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{16}$	—	·0413	60
$\frac{3}{32}$	$1\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{16}$	—	·0671	48
$\frac{1}{8}$	$1\frac{3}{4}$	$\frac{7}{8}$	$\frac{1}{4}$	—	·093	40
$\frac{5}{32}$	$1\frac{7}{8}$	$\frac{7}{8}$	$\frac{1}{4}$	—	·112	32
$\frac{3}{16}$	2	1	$\frac{5}{16}$	—	·134	24
$\frac{7}{32}$	$2\frac{1}{8}$	$1\frac{1}{16}$	$\frac{5}{16}$	—	·165	24
$\frac{1}{4}$	$2\frac{1}{4}$	$1\frac{1}{8}$	$\frac{3}{8}$	—	·186	20
$\frac{5}{16}$	$2\frac{1}{2}$	$1\frac{3}{8}$	$\frac{7}{16}$	$\frac{5}{32}$	·241	18
$\frac{3}{8}$	$2\frac{3}{4}$	$1\frac{1}{2}$	$\frac{1}{2}$	$\frac{7}{32}$	·295	16
$\frac{7}{16}$	$3\frac{1}{4}$	$1\frac{3}{4}$	$\frac{1}{2}$	$\frac{9}{32}$	·346	14
$\frac{1}{2}$	$3\frac{1}{2}$	2	$\frac{9}{16}$	$\frac{5}{16}$	·393	12
$\frac{9}{16}$	$3\frac{3}{4}$	$2\frac{1}{8}$	$\frac{9}{16}$	$\frac{5}{16}$	·455	12
$\frac{5}{8}$	4	$2\frac{1}{4}$	$\frac{5}{8}$	$\frac{3}{8}$	·508	11
$\frac{11}{16}$	$4\frac{1}{4}$	$2\frac{3}{8}$	$\frac{11}{16}$	$\frac{3}{8}$	·571	11
$\frac{3}{4}$	$4\frac{1}{2}$	$2\frac{1}{2}$	$\frac{3}{4}$	$\frac{7}{16}$	·622	10
$\frac{13}{16}$	$4\frac{3}{4}$	$2\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{16}$	·684	10
$\frac{7}{8}$	5	$2\frac{7}{8}$	$\frac{13}{16}$	$\frac{1}{2}$	·732	9
$\frac{15}{16}$	$5\frac{1}{4}$	3	$\frac{13}{16}$	$\frac{1}{2}$	·795	9
1	$5\frac{1}{2}$	$3\frac{1}{4}$	$\frac{7}{8}$	$\frac{5}{8}$	·84	8
$1\frac{1}{8}$	6	$3\frac{1}{2}$	1	$\frac{11}{16}$	·942	7
$1\frac{1}{4}$	$6\frac{1}{2}$	$3\frac{3}{4}$	$1\frac{1}{8}$	$\frac{13}{16}$	1·067	7
$1\frac{3}{8}$	$7\frac{1}{2}$	$4\frac{1}{4}$	$1\frac{1}{8}$	$\frac{13}{16}$	1·161	6
$1\frac{1}{2}$	8	$4\frac{3}{4}$	$1\frac{1}{4}$	1	1·286	6
$1\frac{5}{8}$	$8\frac{1}{2}$	$5\frac{1}{4}$	$1\frac{1}{4}$	1	1·368	5
$1\frac{3}{4}$	9	$5\frac{1}{2}$	$1\frac{3}{8}$	$1\frac{1}{8}$	1·494	5
$1\frac{7}{8}$	$9\frac{1}{2}$	$5\frac{3}{4}$	$1\frac{3}{8}$	$1\frac{1}{8}$	1·59	$4\frac{1}{2}$
2	10	6	$1\frac{1}{2}$	$1\frac{5}{16}$	1·715	$4\frac{1}{2}$
$2\frac{1}{8}$	$10\frac{1}{2}$	$6\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{8}$	1·84	$4\frac{1}{2}$
$2\frac{1}{4}$	11	$6\frac{3}{4}$	$1\frac{5}{8}$	$1\frac{1}{2}$	1·93	4
$2\frac{3}{8}$	$11\frac{1}{2}$	$7\frac{1}{4}$	$1\frac{5}{8}$	$1\frac{5}{8}$	2·054	4
$2\frac{1}{2}$	12	$7\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{5}{8}$	2·18	4
$2\frac{5}{8}$	$12\frac{1}{2}$	$8\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{3}{4}$	2·304	4
$2\frac{3}{4}$	13	$8\frac{3}{4}$	$1\frac{7}{8}$	$1\frac{3}{4}$	2·384	$3\frac{1}{2}$
$2\frac{7}{8}$	$13\frac{1}{2}$	$9\frac{3}{4}$	$1\frac{7}{8}$	$1\frac{7}{8}$	2·509	$3\frac{1}{2}$
3	14	$10\frac{3}{4}$	2	2	2·634	$3\frac{1}{2}$

WHITWORTH'S STANDARD HEXAGON NUTS AND BOLTS.

Size of Bolt and thickness of Nut.	Nut across Flats.	Nut across Corners.	Tapping Hole.	Thickness of Bolt-head.
$\frac{1}{8}$	·338	·390	·093	·1093
$\frac{3}{16}$	·448	·517	·134	·164
$\frac{1}{4}$	·525	·606	·186	·2187
$\frac{5}{16}$	·601	·694	·241	·2734
$\frac{3}{8}$	·709	·819	·295	·3281
$\frac{7}{16}$	·820	·947	·346	·3828
$\frac{1}{2}$	·920	1·06	·393	·4375
$\frac{9}{16}$	1·01	1·16	·455	·4921
$\frac{5}{8}$	1·1	1·27	·508	·5468
$\frac{11}{16}$	1·2	1·38	·571	·6016
$\frac{3}{4}$	1·3	1·5	·622	·6562
$\frac{13}{16}$	1·39	1·6	·684	·7064
$\frac{7}{8}$	1·48	1·7	·732	·7656
$\frac{15}{16}$	1·57	1·82	·795	·8203
1	1·67	1·95	·84	·875
$1\frac{1}{8}$	1·86	2·15	·942	·9843
$1\frac{1}{4}$	2·05	2·36	1·06	1·0937
$1\frac{3}{8}$	2·21	2·55	1·16	1·2031
$1\frac{1}{2}$	2·41	2·78	1·28	1·3125
$1\frac{5}{8}$	2·57	2·97	1·37	1·4128
$1\frac{3}{4}$	2·75	3·18	1·49	1·5312
$1\frac{7}{8}$	3·02	3·48	1·59	1·6406
2	3·15	3·63	1·71	1·75
$2\frac{1}{8}$	3·34	3·85	1·84	1·8523
$2\frac{1}{4}$	3·54	4·09	1·93	1·9687
$2\frac{3}{8}$	3·75	4·33	2·05	2·0781
$2\frac{1}{2}$	3·89	4·49	2·18	2·1875
$2\frac{5}{8}$	4·05	4·67	2·30	2·2968
$2\frac{3}{4}$	4·18	4·82	2·39	2·4062
$2\frac{7}{8}$	4·34	5·02	2·5	2·5156

Whitworth's Standard Hexagon Nuts and Bolts—*Continued.*

Size of Bolt and thickness of Nut.	Nut across Flats.	Nut across Corners.	Tapping Hole.	Thickness of Bolt-head.
3	4·53	5·23	2·63	2·625
$3\frac{1}{8}$	4·69	5·41	2·75	2·7343
$3\frac{1}{4}$	4·85	5·60	2·85	2·8256
$3\frac{3}{8}$	5·01	5·78	2·98	2·9531
$3\frac{1}{2}$	5·17	5·98	3·1	3·0624
$3\frac{5}{8}$	5·36	6·19	3·23	3·1718
$3\frac{3}{4}$	5·55	6·41	3·32	3·2812
$3\frac{7}{8}$	5·75	6·64	3·45	3·3906
4	5·95	6·87	3·57	3·5
$4\frac{1}{8}$	6·16	7·11	3·69	3·6094
$4\frac{1}{4}$	6·37	7·36	3·8	3·7046
$4\frac{3}{8}$	6·60	7·62	3·93	3·8271
$4\frac{1}{2}$	6·82	7·88	4·05	3·9374
$4\frac{5}{8}$	7·06	8·15	4·18	4·0469
$4\frac{3}{4}$	7·3	8·43	4·28	4·1562
$4\frac{7}{8}$	7·55	8·72	4·4	4·2656
5	7·8	9·01	4·53	4·375
$5\frac{1}{8}$	8·06	9·31	4·66	4·4844
$5\frac{1}{4}$	8·35	9·64	4·76	4·5936
$5\frac{3}{8}$	8·6	9·93	4·88	4·7031
$5\frac{1}{2}$	8·85	10·22	5·01	4·8124
$5\frac{5}{8}$	9·15	10·57	5·13	4·9218
$5\frac{3}{4}$	9·45	10·91	5·24	5·0312
$5\frac{7}{8}$	9·75	11·26	5·36	5·1406
6	10·	11·55	5·48	5·25

AMERICAN STANDARD HEXAGON NUTS AND BOLTS (SELLERS').

Size of Bolt and Thickness of Nut.	Nut across Flats.	Nut across Corners.	Tapping Hole.	Thickness of Bolt-head.
1/4	·5	·577	·185	·197
5/16	·597	·685	·240	·2472
3/8	·687	·794	·294	·2954
7/16	·781	·902	·345	·3447
1/2	·875	1·0106	·4	·394
9/16	·968	1·1187	·454	·4432
5/8	1·062	1·227	·506	·4925
3/4	1·25	1·443	·62	·591
7/8	1·437	1·66	·731	·6895
1	1·625	1·876	·837	·788
1 1/8	1·812	2·093	·939	·8864
1 1/4	2·	2·31	1·064	·985
1 3/8	2·187	2·526	1·158	1·0764
1 1/2	2·375	2·743	1·283	1·182
1 5/8	2·562	2·959	1·389	1·2805
1 3/4	2·75	3·176	1·49	1·379
1 7/8	2·937	3·393	1·615	1·477
2	3·125	3·609	1·711	1·576
2 1/4	3·5	4·042	1·961	1·7628
2 1/2	3·875	4·475	2·175	1·97
2 3/4	4·25	4·908	2·425	2·1528
3	4·625	5·341	2·628	2·364
3 1/4	5·	5·775	2·878	2·561
3 1/2	5·375	6·208	3·1	2·758
3 3/4	5·75	6·641	3·317	2·954
4	6·125	7·074	3·567	3·152
4 1/4	6·5	7·507	3·798	3·349
4 1/2	6·875	7·94	4·027	3·5256
4 3/4	7·25	8·373	4·255	3·743
5	7·625	8·806	4·48	3·94
5 1/4	8·	9·24	4·73	4·137
5 1/2	8·375	9·67	4·953	4·334
5 3/4	8·75	10·106	5·203	4·531
6	9·125	10·539	5·423	4·728

TABLE OF DECIMAL EQUIVALENTS

OF

8ths, 16ths, 32nds, and 64ths of an Inch.

$\frac{1}{64}$ = ·015625	$\frac{11}{32}$ = ·34375	$\frac{43}{64}$ = ·671875
$\frac{1}{32}$ = ·03125	$\frac{23}{64}$ = ·359375	$\frac{11}{16}$ = ·6875
$\frac{3}{64}$ = ·046875	$\frac{3}{8}$ = ·375	$\frac{45}{64}$ = ·703125
$\frac{1}{16}$ = ·0625	$\frac{25}{64}$ = ·390625	$\frac{23}{32}$ = ·71875
$\frac{5}{64}$ = ·078125	$\frac{13}{32}$ = ·40625	$\frac{47}{64}$ = ·734375
$\frac{3}{32}$ = ·09375	$\frac{27}{64}$ = ·421875	$\frac{3}{4}$ = ·75
$\frac{7}{64}$ = ·109375	$\frac{7}{16}$ = ·4375	$\frac{49}{64}$ = ·765625
$\frac{1}{8}$ = ·125	$\frac{29}{64}$ = ·453125	$\frac{25}{32}$ = ·78125
$\frac{9}{64}$ = ·140625	$\frac{15}{32}$ = ·46875	$\frac{51}{64}$ = ·796875
$\frac{5}{32}$ = ·15625	$\frac{31}{64}$ = ·484375	$\frac{13}{16}$ = ·8125
$\frac{11}{64}$ = ·171875	$\frac{1}{2}$ = ·50	$\frac{53}{64}$ = ·828125
$\frac{3}{16}$ = ·1875	$\frac{33}{64}$ = ·515625	$\frac{27}{32}$ = ·84375
$\frac{13}{64}$ = ·203125	$\frac{17}{32}$ = ·53125	$\frac{55}{64}$ = ·859375
$\frac{7}{32}$ = ·21875	$\frac{35}{64}$ = ·546875	$\frac{7}{8}$ = ·875
$\frac{15}{64}$ = ·234375	$\frac{9}{16}$ = ·5625	$\frac{57}{64}$ = ·890625
$\frac{1}{4}$ = ·25	$\frac{37}{64}$ = ·578125	$\frac{29}{32}$ = ·90625
$\frac{17}{64}$ = ·265625	$\frac{19}{32}$ = ·59375	$\frac{59}{64}$ = ·921875
$\frac{9}{32}$ = ·28125	$\frac{39}{64}$ = ·609475	$\frac{15}{16}$ = ·9375
$\frac{19}{64}$ = ·296875	$\frac{5}{8}$ = ·625	$\frac{61}{64}$ = ·953125
$\frac{5}{16}$ = ·3125	$\frac{41}{64}$ = ·640625	$\frac{31}{32}$ = ·96875
$\frac{21}{64}$ = ·328125	$\frac{21}{32}$ = ·65625	$\frac{63}{64}$ = ·984375

SPECIAL TABLE FOR CUTTING SCREWS ON WHITWORTH'S LATHE, HAVING ¼ PITCH GUIDE-SCREW AND A PINION OF 15 TEETH.

Threads per Inch.	Wheel on Mandrel.	Stud Wheel.	Stud Pinion.	Wheel on Leading Screw.	Threads per Inch.	Wheel on Mandrel.	Stud Wheel.	Stud Pinion.	Wheel on Leading Screw.
1	80	—	—	20	20	60	45	15	100
1¼	80	—	—	25	21	40	45	15	70
1½	80	—	—	30	22	60	45	15	110
1¾	80	—	—	35	24	40	45	15	80
2	90	—	—	45	25	40	50	15	75
2¼	80	—	—	45	26	60	65	15	90
2½	80	—	—	50	28	60	70	15	90
2¾	80	—	—	55	30	60	75	15	90
3	100	—	—	75	32	30	40	15	90
3¼	80	—	—	65	33	40	55	15	90
3½	80	—	—	70	34	30	45	15	85
3¾	80	—	—	75	36	40	60	15	90
4	90	—	—	90	38	30	45	15	95
4¼	80	—	—	85	40	30	50	15	90
4½	80	—	—	90	44	30	55	15	90
4¾	80	—	—	95	48	20	40	15	90
5	80	—	—	100	50	20	50	15	75
5½	80	—	—	110	54	20	45	15	90
6	60	—	—	90	57	20	45	15	95
7	40	—	—	70	60	20	50	15	90
8	40	—	—	80	66	20	55	15	90
9	80	30	15	90	70	20	70	15	75
10	60	25	15	90	76	30	90	15	95
11	80	30	15	110	80	30	90	15	100
12	100	60	15	75	88	30	90	15	110
13	80	60	15	65	96	20	80	15	90
14	60	35	15	90	100	20	75	15	100
15	80	45	15	100	110	20	75	15	110
16	60	45	15	80	114	20	90	15	95
17	60	45	15	85	120	20	90	15	100
18	80	60	15	90	132	20	90	15	110
19	80	60	15	95					

CHAPTER XIV.

THE MILLING MACHINE.

THE most important advancement in machine tools made in recent years is probably in the milling machine. Though the machine and the principles of revolving cutters for working metals have been in use for a long time, it is comparatively recently that the system has been perfected. Now the milling machine is fast superseding shaping and planing machines for many processes, where the capabilities of the milling machine are understood. A chapter on this important machine, showing some of the varieties made by the BRITANNIA COMPANY, of Colchester, will therefore be interesting to nearly every reader of SCREWS AND SCREW-MAKING.

A single-geared milling machine is shown at Fig. 81. This is a machine specially suited for engineers, brass finishers, gun smiths, sewing machine, bicycle, and other small machine makers. It has a steel mandrel with conical neck, steel lock nuts to take up wear and receive thrust in face work, and the nose is screwed and coned for chucks. It is fitted with longitudinal, tranverse, and vertical slides; is self-acting in longitudinal by improved worm and wheel feed, and the vertical is actuated by a convenient wheel and screw movement in front. A tray for tools is fitted at the side. An over-head motion with fast and loose, and cone pulleys, countershaft, hangers, and strap-shifting gear is included in the price. When required for milling squares, hexagons, octagons, &c., as nuts or brass cocks and fittings, a very convenient dividing appliance can be supplied as shown on the illustration.

The slides traverse 11½in. longitudinally, 4½in. transversely, and 12in. vertically. Work table is 8in. × 6in., with **T** grooves; cone pulley has 4 speeds for 2in. belt; total height is 3ft. 2in.; approximate weight 5 cwt. Price, complete, £24; Dividing appliance, £2 10s.

A double-geared milling machine is shown at Fig. 82. The knee-slide is accurately fitted to the front of the body or

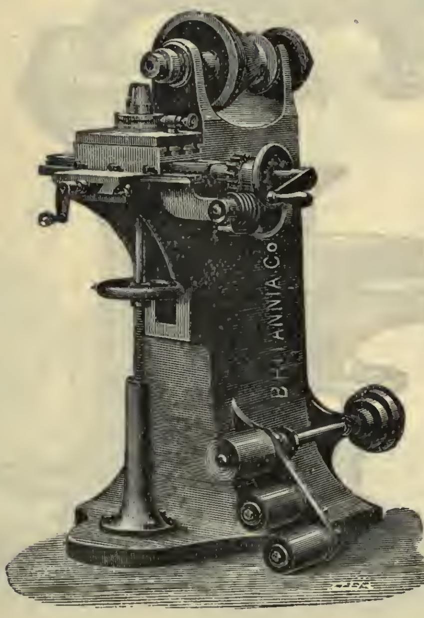


FIG. 81. SINGLE-GEARED MILLING MACHINE.

column, and rises and falls 14in., giving 15½in. from top of work-table to centre of mandrel when at its lowest, and is adjusted by a vertical screw and conveniently-placed hand-wheel. The longitudinal slide is 24in. long and 7½in. wide, and has a traverse parallel with axis of spindle of 7½in., adjusted by hand-wheel and screw.

The work-table is 14in. long and 8½in. wide, with T slots for fixing the work, and has a traverse of 18in., self-acting by worm and wheel and friction cone. The belt cone pulley for self-acting feed has three steps, which give, with the back gearing, six changes of speed.

FIG. 82. DOUBLE-GEARED MILLING MACHINE.

All the slides are accurately scraped and fitted, and have loose angle strips to adjust for wear. All traversing screws are steel, and all material is of the best. The whole is fitted and finished in a superior manner, making a thoroughly reliable machine.

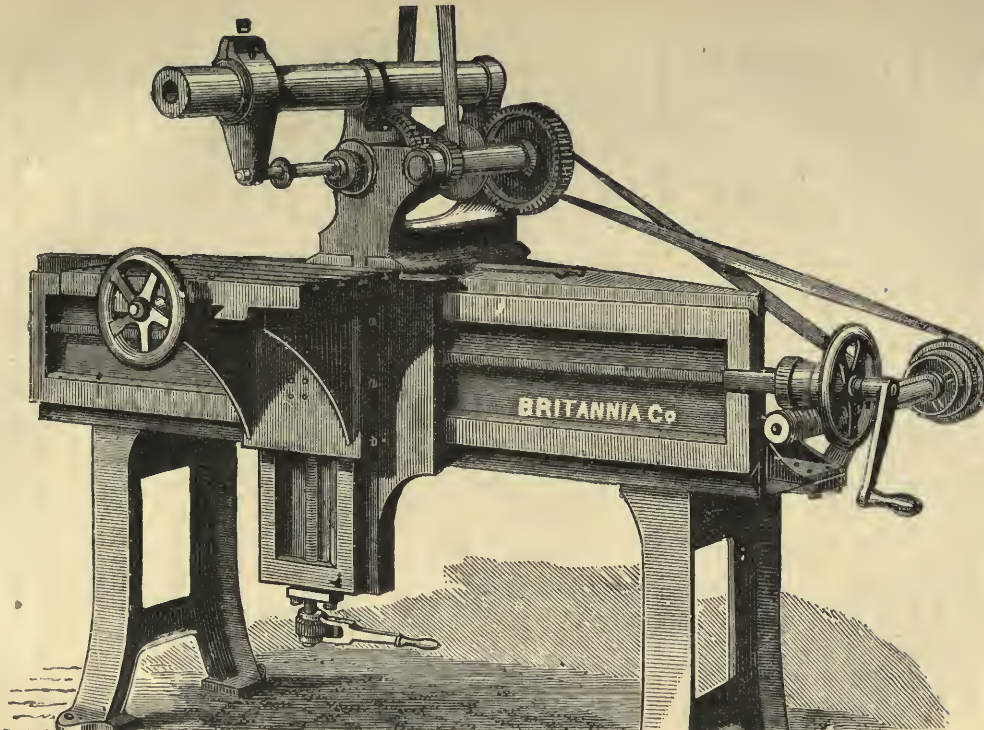


FIG. 83. NEW UNIVERSAL MILLING MACHINE.

O

Dimensions.—Height over all, 4ft. 4in.; width, 3ft.; depth, 4ft.; diameter of mandrel, $1\frac{5}{8}$in.; cone pulley has 4 speeds, $2\frac{1}{4}$in. wide; diameter of largest speed $8\frac{1}{2}$in., and of smallest, $3\frac{3}{4}$in.; gearing is $\frac{5}{8}$in. pitch, and 2in. on face, diameters, 10in. and $3\frac{1}{4}$in.; diameter of fast and loose pulleys, 10in. and 3in. wide; weight, about 12 cwt. Price, including top driving apparatus, screw-keys, &c., complete, £45. Parallel vice with swivelling jaw to suit, £3 5s. Dividing appliance with tangent screw and worm-wheel for squares, hexagons, &c., £3 15s.

The BRITANNIA COMPANY's New Engineers' Universal Milling Machine is shown at Fig. 83. This is a very useful machine, capable of a large range of work, and will be found a great economiser of labour. From the illustration (Fig. 83) the principal features of the machine will be readily understood. The bed is 6ft. long, self-acting through its whole length. It is fitted with rack and pinion to work the saddle back quickly. The table has a traverse of 12in. vertically and of 9in. horizontally. The head-stock is back-geared and with 4-speed cone pulley for $2\frac{1}{4}$in. strap. The gearing is $1\frac{3}{4}$in. wide and $\frac{5}{8}$in. pitch, and is put in and out by an eccentric. The mandrel is of cast steel, running through, and with coned bearings. The neck of the mandrel is $2\frac{1}{4}$in. diameter, and the nose bored conically 2in. deep and 1in. diameter, and tapped beyond to take spindles for milling cutters. A strong adjustable arm B is used to support outer end of mandrel when necessary, and can be readily removed when not required.

By using the arm very wide cutters or a series of cutters can be used for wide surfaces or any irregular form which may be required. This machine has many advantages over planing machines in point of variety of uses to which it can be put, as well as its more rapid operation. Price, including over-head motion, one mandrel and spanner, £60.

Fig. 84 shows a strong pattern dividing appliance for engineers. Especially adapted for use with milling, shaping or other similar machines.

This appliance has a cast-iron planed bed, with T slots to bolt on to the machine table, and has quadrant slots, to allow of adjustment to any angle, for cutting worm-wheels, angled

tooth cutters, &c. The fast head is constructed for the spindle to be elevated and locked at either horizontal, vertical, or any intermediate angle, and has a graduated quadrant.

. The spindle is moved for dividing by steel worm and wheel, and the worm-shaft carries a division plate with 5 rows of holes capable of dividing (with the worm gearing) up to 360 degrees. A piston stop and sextant finger are also provided. The main spindle is hollow, and coned for other mandrels than that supplied as may be required. All parts are adjustable for taking up back lash and wear, and are of the best materials and workmanship, and very accurately fitted. Height of centres, 4in.; length of bed, 2ft.; takes between centres, 11in. Price, £14 10s.

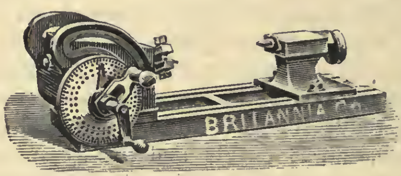


FIG. 84. DIVIDING APPLIANCE.

A handy patented appliance for milling on the lathe is shown at Figs. 85 and 86. This appliance is made by the BRITANNIA COMPANY, Colchester, and intended to be fixed on the lathe bed at a convenient distance from the head-stock. A suitable chuck on the mandrel nose holds the cutting tool, and it is convenient to make a false nose to fit in the socket (A, Figs. 85 and 86) so that the lathe chucks can be screwed on the appliance.

To explain the use of this appliance, suppose we have to mill the faces of a hexagon nut. A tool like Fig. 90 is fixed in a drill-chuck on the lathe, and the hexagon nut is screwed on a peg which is fitted in the socket A, and held firmly by the clamping-screw B, Figs. 85 and 86. The vertical height is adjusted by means of the hand-wheel, shown in top and side views, but not lettered, so as to bring the middle of the

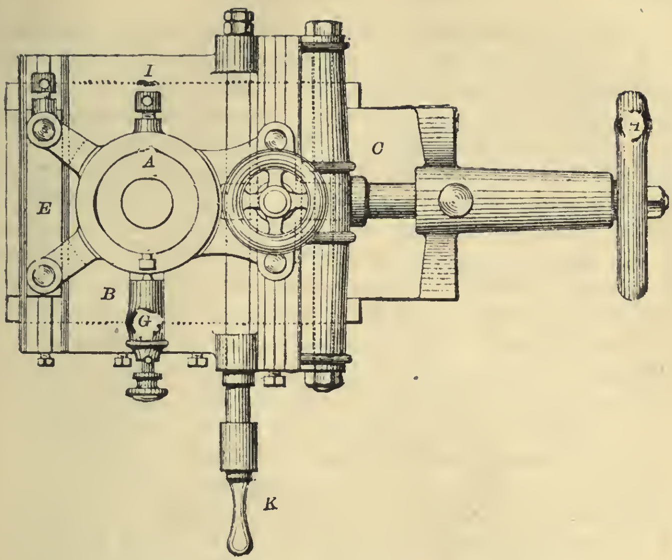


FIG. 85 TOP VIEW OF MILLING APPLIANCE FOR LATHE.

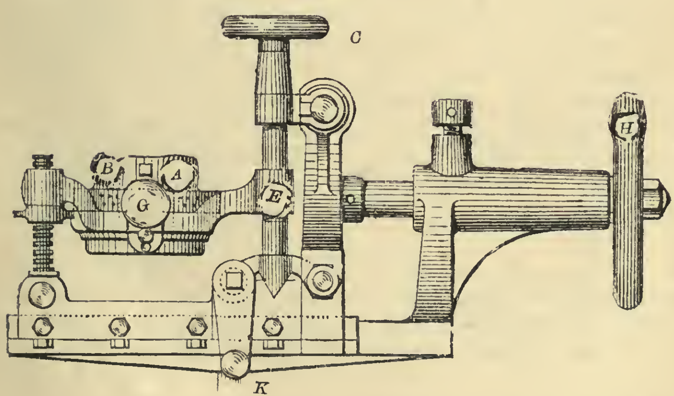


FIG. 86. FRONT VIEW OF MILLING APPLIANCE.

nut about on a level with the lathe centres. The nut D is brought up to support the table E, and the set-screw F is tightened. The point of the spring catch G is adjusted to the level of the required circle of holes in the division plate, that having twenty-four will suit in this case, and taking each fourth hole will give the six divisions required for the hexagon nut. The socket is fastened by the set-screw I, and the work is adjusted to bring it into cut by means of the hand-wheel H. When the lathe is running at a fair rate of speed the work is traversed across the cutter by means of the handle K. The nut is rotated half-way in the socket and the work again traversed across the cutter. This will face two opposite flats of the nut. These are gauged, and the work adjusted to make the nut the required size; then by repeating the cut six times the nut will be finished a true hexagon.

Drilling and shaping by means of cutters having the desired form is readily done in the same way by using a drill or other tool in place of Fig. 90. The adjustments are made vertically by the wheel C and horizontally by the handle K, the work being fed into cut by the hand-wheel H.

These two processes represent the principle upon which an endless variety of ornamental work in hard wood or metal can be executed, the cutting edge of the tool being turned to the required pattern; always remembering, if the work is concave, to turn the tool convex; and so on, with reference to mouldings and raised or sunk forms, and with perforations for drilled designs and coronas for lids, and the many methods of ornamenting turned work, bounded only by the taste of the operator. These remarks concerning ornamental work apply even more forcibly to the use of the combination chuck which is next illustrated.

The three Figs. which follow (87, 88, and 89) show the top end and side views respectively of a combination chuck intended for use in the milling appliance just described. The piece marked A in Figs. 88 and 89 fits in the socket marked A, Figs. 85 and 86.

Before fixing the combination chuck in the socket A of the appliance, see that the clamping-screw, B, faces the lathe

head-stock, also that the spring-catch is in one of the division holes, and the set-screw, I, securely tightened; the chuck can now be secured to the socket A by the clamping-screw B, Fig. 85.

Suppose a tap is to be fluted, place the tap between the centres C, Figs. 87 and 89, securing it by the clamps B, tightening up by the screw D. A round-nose tool, Fig. 93, is used, and the centre line of the tap adjusted to the centre of the tool; or if

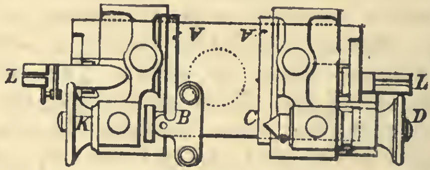


FIG. 87. TOP VIEW OF COMBINATION CHUCK FOR MILLING APPLIANCE.

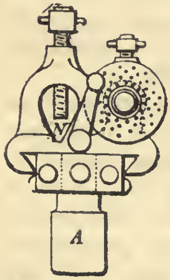


FIG. 88. END VIEW OF COMBINATION CHUCK.

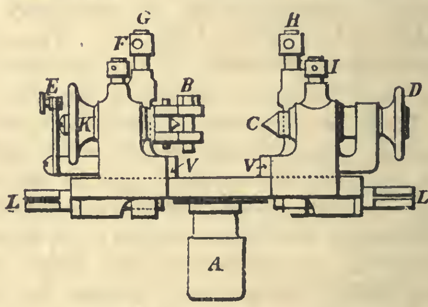


FIG. 89. SIDE VIEW OF COMBINATION CHUCK.

the tap is a little below the centre of the tool, it gives a more acute cutting edge; one size round-nose fluting-tool will flute several sizes of taps. Engage the spring-catch E, Fig. 89, with the requisite series of division holes in disc K, and traverse the tap across the tool by the handle K, Figs. 85 and 86, until the flute is the required depth, then set it by the division holes for the next groove, and so on, until the flutings are completed.

Suppose a slot is to be cut in a rod, place the rod in the **V** gap.

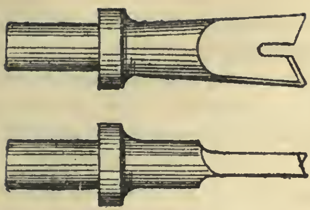


FIG. 90. NUT-SHAPING CUTTER.

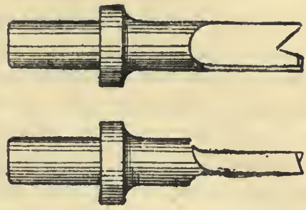


FIG. 91. SLOTTING TOOL.

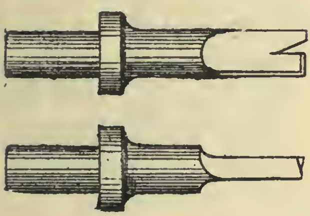


FIG. 92. KEYWAY CUTTER.

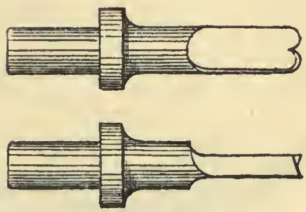


FIG. 93. ROUND NOSE FLUTING TOOL.

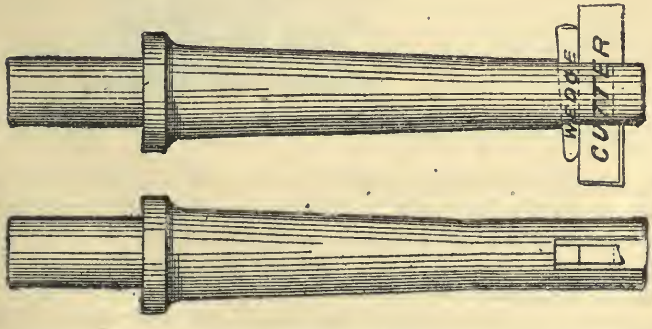


FIG. 94. BORING TOOL.

Fig. 89, fasten down by the screws G, H; use a tool, Fig. 91. It is the best to drill a hole at the extreme ends of the slot required. Let the centre line of the rod be exactly opposite the centre of the tool; then traverse as in fluting. For key-way cutting, see that the tool is shaped like Fig. 92.

To use the chuck as a vice, remove the clamps B, Figs. 87 and 89, by withdrawing the screws, and then objects can be gripped for shaping, drilling, boring, or any other operation within the

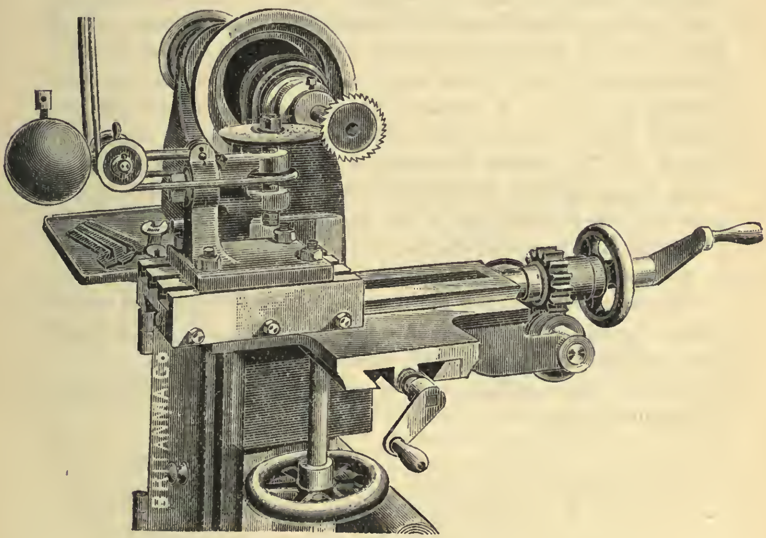


FIG. 95. APPLIANCE FOR SHARPENING MILLING CUTTERS, ETC.

range of the apparatus. Fig. 94 is a convenient tool for boring; a small cylinder can be gripped in the vice and bored with accuracy by following the lines already given, but it is not well to stop until the cut is through.

Fig. 95 shows an appliance made by the BRITANNIA COMPANY, Colchester, for sharpening milling-cutters, &c. Milling-cutters must be kept sharp and true to ensure economy in work.

The illustration shows the appliance on the table of an ordinary milling machine as used sharpening a cutter. The emery-grinder is intended to be driven from the countershaft of the machine. It is adjusted by the slides of the machine to correct position for grinding the cutter, which is meantime held in its usual position on the mandrel, the driving belt of the latter being, of course, thrown off for the time.

The appliance is constructed with a firm base to bolt to machine table, and has a swivelling head carrying a steel spindle with driving pulley fitted, and arranged to hold an emery-wheel at its end. It has a pair of guide pulleys which swivel and slide upon a hinged lever, with a heavy weight at its end to keep the driving gut tight. In operation the emery-wheel is brought into contact with a tooth of the cutter, and is traversed across the face of it. The cutter is turned by moving the cone pulley by hand, bringing each tooth successively in contact. The appliance can also be used with a square-edged emery-wheel, to run in a vertical direction, and sharpen the cutter by grinding the tops of the teeth, which is sometimes preferable.

The emery-wheel being fitted to swivel can be arranged to suit cutters having teeth cut square across or oblique. It is useful also for backing off taps and reamers, flute-drills, &c.

Price of the appliance, £4, or with over-head for driving it independently, £6 10s.

INDEX.

M.

N.

O.

P.

Q.

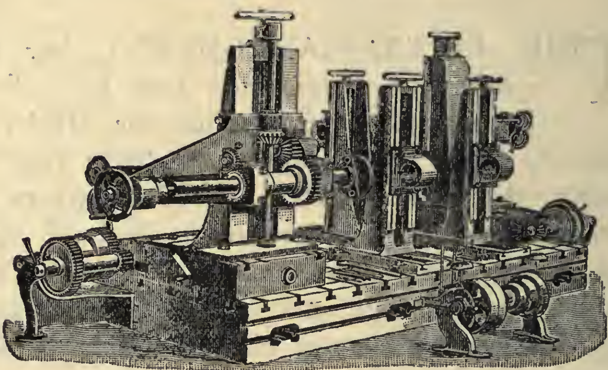
R.

S.

Horizontal Boring, Drilling, and Surfacing Machine.

FOR LARGE WORK.

AS MADE FOR DAVEY PAXMAN & CO.



THESE machines are constructed with powerfully geared boring heads, having steel spindles, driven by strong spur and mitre gearing with variable feed, self-acting in either direction, or stationary for surfacing; the heads are mounted on upright, heavy, rigidly-constructed slides, with vertical adjustment by screw and hand-wheel, and transverse adjustment by rack and pinion. The upright bar rests are made with socket heads to carry the boring bar and bushes, one bar rest at each side of the work, and are also adjustable vertically by screws and hand-wheels. The driving cone pulleys have four speeds, and double gearing is fitted, giving eight changes of speed. The whole is mounted on a machine-planed heavy foundation bed-plate, with T slots for bolting work to. The machine above illustrated has steel spindles 3¼in. diameter, and is capable of boring holes up to 24in. diameter by 42in. long, and has a double set of boring heads and bar rests, the foundation plate being 12ft. by 5ft.; but the machines are made of all sizes, to suit Purchasers' requirements, and Estimates will be given on application.

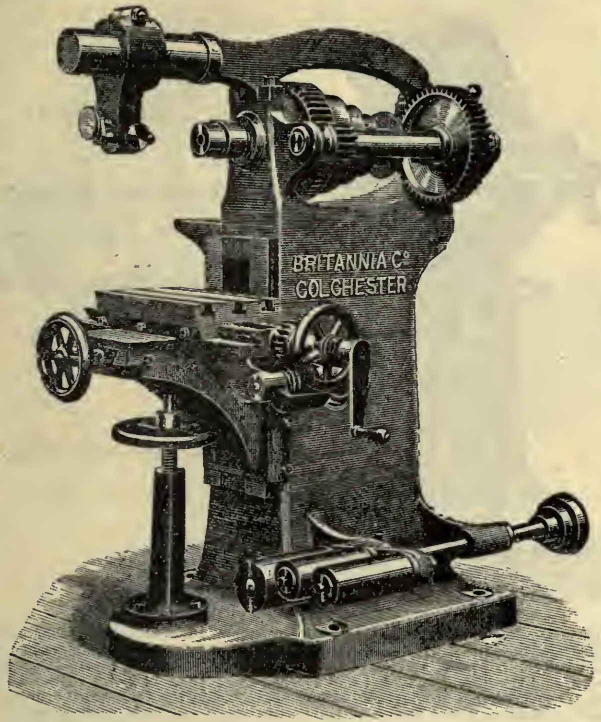
Price of above Machine on rails at Colchester, with top-driving apparatus, &c., complete, **£200.**

Weight, about 7½ tons.

Smaller Machines, driven by single gear, boring up to 12in. diameter, made on similar principle—Price with bed 13ft. by 5ft., to bore up to 12in. hole, £120. Other sizes to order.

MILLING MACHINE, No. 12 DOUBLE GEARED.

Improved Apparatus for Sharpening Cutters, £6 10s.



Tel. Code M 2

Cutters made to any shape to order.

THE knee-slide is accurately fitted to the front of the body or column, and rises and falls 14in., giving 15½in. from top of work-table to centre of spindle when at its lowest, and is adjusted by a vertical screw and conveniently-placed hand-wheel. The longitudinal slide is 24in. long and 7½in. wide, and has a transverse traverse—*i.e.*, parallel with axle of spindle—of 7½in., adjusted by hand-wheel and screw

The work-table is 14in. long and 8½in. wide, with T slots planed out for fixing the work, and has a longitudinal traverse of 18in., self-acting by worm and wheel, and friction cone. The belt cone-pulley for self-acting feed has three steps, which give, with the back gearing, six changes of speed.

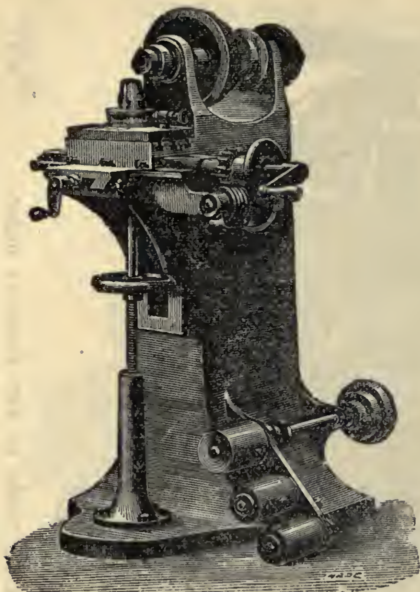
All the slides are accurately scraped and fitted, and have loose angle strips to adjust for wear. All traverse screws are steel, and all material is of the best. The whole is fitted and finished in a superior manner, and is a thoroughly reliable tool.

DIMENSIONS.—Height over all, 4ft. 4in.; Width, 3ft.; Depth, 4ft.; Diameter of main spindle, 1⅝in.; Cone Pulley has four speeds, 2¼in. wide; Diameter of largest speed, 8½in., and of smallest, 3¾in.; Gearing is ⅝in. pitch, and 2in. on face; Diameters of Gearing, 10in. and 3¼in.; Diameter of fast and loose pulleys, 10in. and 3in. wide; Total weight, about 12cwt.

PRICE, including top driving apparatus, screw keys, &c., &c., complete	£45 0 0
Parallel Vice, with swivelling jaw to suit	£3 5 0
Dividing appliance, with tangent worm and wheel for squares, hexagons, &c.	£3 15 0

TWO LARGER-SIZED MILLING MACHINES. See SPECIAL CIRCULAR, or CATALOGUE.

MILLING MACHINE, No. 10 Single Geared.



Tel. Code—M 1

Improved Apparatus

for

Sharpening Cutters,

£6 10 0

Cutters made to any

Shape to Order.

THIS is a machine specially suited for Engineers, Brass-finishers, Gunsmiths; Sewing Machine, Bicycle, and other small machine makers. It has a steel spindle with conical neck, steel lock-nuts to take up wear and receive thrust in face work, and the nose is screwed and coned for chucks. It is fitted with longitudinal, transverse, and vertical slides; is self-acting in longitudinal by the most improved worm and wheel feed, and the vertical actuated by a convenient wheel and screw movement in front. A tray for tools is fitted at the side. An overhead motion with fast and loose and cone pulleys, countershaft, hangers, and strap shifting gear, is included in the price. When required for milling squares, hexagons, octagons, &c., as nuts or brass cocks and fittings, a very convenient dividing appliance can be supplied, as shown on the illustration.

DIMENSIONS AND PRICES:—

The Slides traverse Longitudinally	... ...	11½ inches.
„ „ Transversely	... ...	4½ „
„ „ Vertically	... ...	12 „

Work Table is 8in. by 6in., with T grooves.

Cone Pulley has 4 speeds for 2in. belt.

Total Height is 3ft. 2in Approximate Weight, 5cwt.

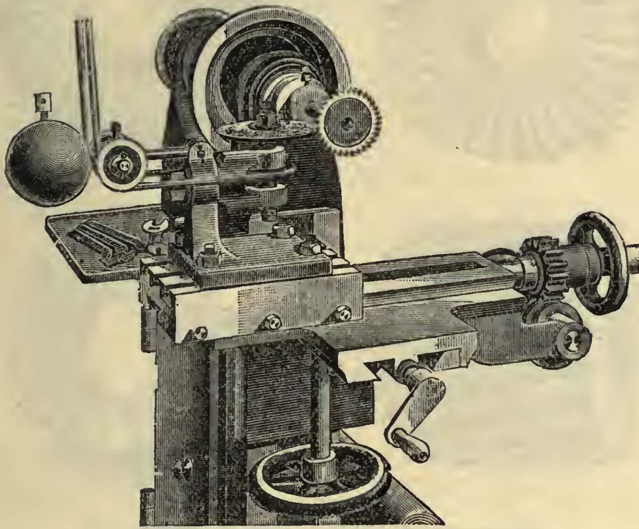
Price, Complete	£24 0 0
Dividing Appliance	2 10 0
Parallel Vice to suit	2 0 0

PATENT MILLING MACHINES, to work on 5in., 6in., or 7in. Centre Lathes.

For Prices and Specifications, see Special Circular.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

Appliance for Sharpening Cutters for Milling Machines, &c.



Indispensable to every Milling Machine.
Cutters kept sharp and true, ensuring economy in work.

THE above appliance, illustrated as in use on a Milling Machine, is designed as a handy device to fit on to the table of an ordinary Milling Machine to sharpen its cutters. It is driven from the countershaft of the machine, and adjusted to correct position for grinding by the slides of the machine, the cutter to be sharpened being held in its usual position as for cutting, in the mandrel of the headstock, the driving belt of the latter being of course thrown off for the time.

It is constructed to bolt to machine table, and has a swivelling head, carrying a steel spindle with driving pulley fitted, to hold an emery wheel at its end, as shown.

It has a pair of guide pulleys, which swivel and slide upon a hinged lever, with a weight at its end to tighten the gut.

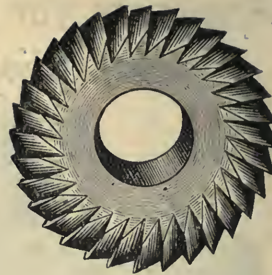
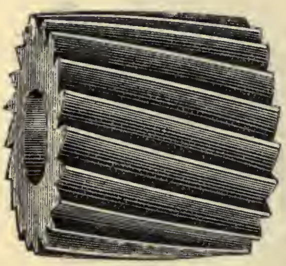
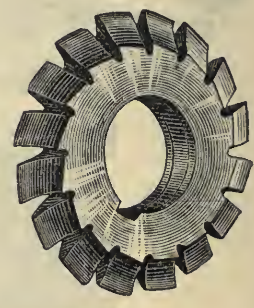
When in operation the emery wheel is brought into contact with the cutter, which is turned by moving the cone-pulley by hand, bringing each successive tooth in contact with the emery wheel.

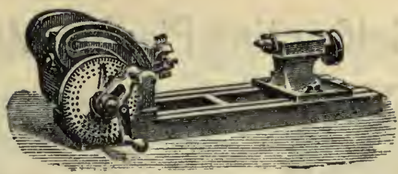
The emery wheel being fitted to swivel, can be arranged to suit cutters having teeth cut square across or obliquely, and can also be used with a square-edged emery wheel, to run in a vertical direction, and sharpen the cutter by grinding the tops of the teeth, which is sometimes preferable.

It is useful also for backing off taps and reamers, flute drills, &c.

Price of the Appliance	**£4**	**0**	**0**
Or with complete Overhead for driving it independently ...	**£6**	**10**	**0**

BRITANNIA WORKS, COLCHESTER, ENGLAND.

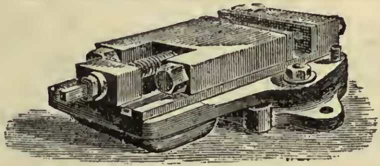



DIVIDING APPLIANCE,

FOR MILLING AND SHAPING,

Price £14 10s. 0d.

AS SUPPLIED TO THE ROYAL ARSENAL.



ENGINEER'S VICE

(STRONG PATTERN, WITH SWIVEL BOTTOM),

FOR MILLING AND PLANING.

Price £5 10s.

Ordinary Pattern Planer Vices, to take in 4in. to 12in., Prices 40/- to 115/-

DRILLING MACHINES IN GREAT VARIETY,

From 50s. upwards.

PLANING MACHINES, SHAPING MACHINES, SLOTTING MACHINES.

MILLING MACHINES (4 Patterns):

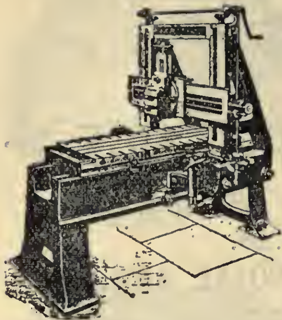
Our largest will mill six surfaces 4ft. at one operation.

☞ TOOLS DESIGNED, OR MADE TO DRAWING,

For Special Work.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

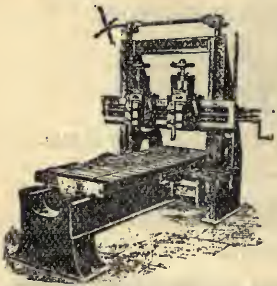
Improved Self-acting Planing Machine.



THESE Planers are constructed with the recent improvements. Self-acting in horizontal, vertical, and angular cuts, with quick return. The slides are fitted with oil-cups. They are adapted for hard and accurate wear. Spanners are included.

Tel. Code.	Height.	Width.	Length.	Price.	Approximate Weight.	Extra per Foot long.
P 1	2ft.	2ft.	4ft.		31cwt.	
P 2	2ft.	2ft.	6ft.		39cwt.	

Powerfully-Geared Self-Acting Planing Machine.



THIS is a newly-designed Planer, embracing the latest improvements. It is self-acting in vertical, horizontal, and angular cuts; self-oiling lubricators. The material and workmanship is guaranteed, and the gearing is strong and accurate. Spanners, &c., are included.

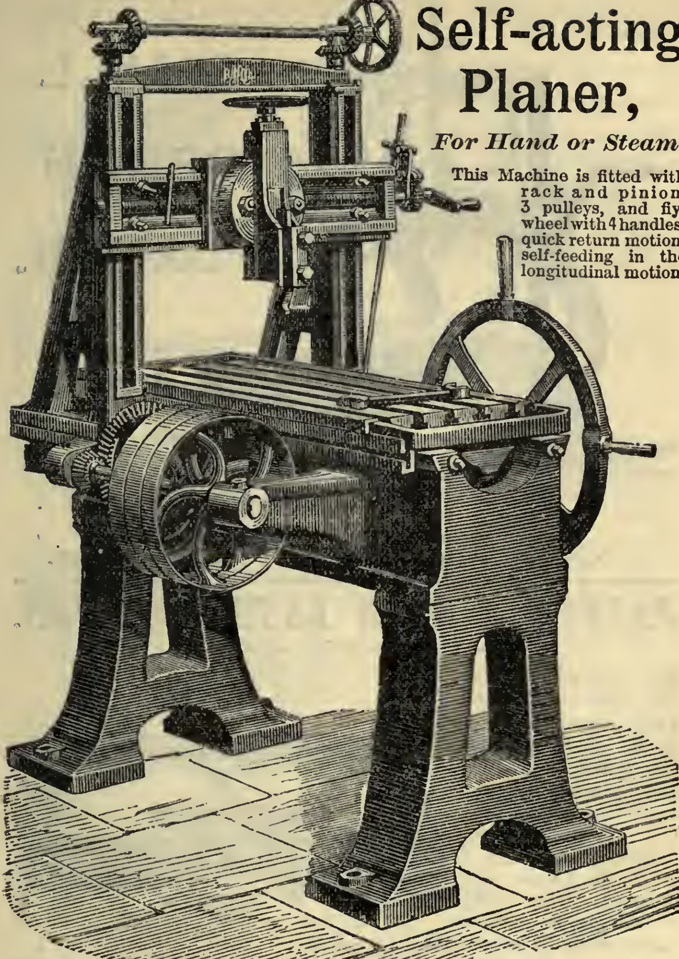
Tel. Code.	Height.	Width.	Length.	Price.	Approximate Weight.	Extra per Foot long.	For Extra Tool-Box.
P 3	2ft. 6in.	2ft. 6in.	6ft.		55cwt.		
P 4	3ft. 3in.	3ft. 3in.	6ft.		70cwt.		

Special Quotations for Planers up to 20ft. Beds by 6ft. by 6ft.

Self-acting Planer,

For Hand or Steam.

This Machine is fitted with rack and pinion, 3 pulleys, and fly-wheel with 4 handles; quick return motion, self-feeding in the longitudinal motion.

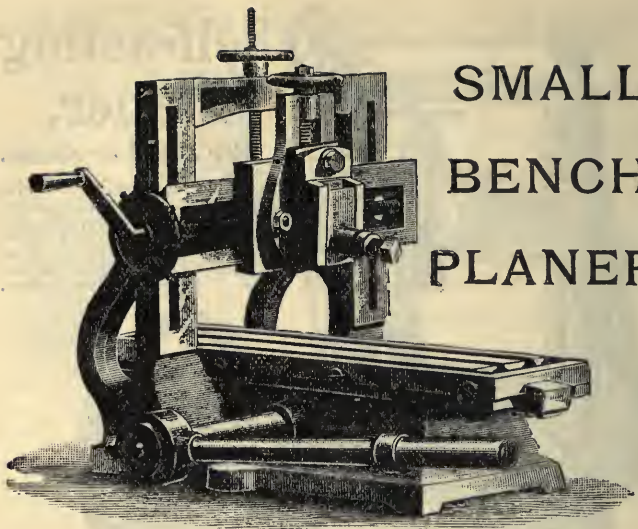


No. 1 Machine, without Base, £20.

	No. 1.	No. 2.	No. 3.
Will take in Long	16in.	24in.	32in.
,, ,, Wide	12in.	16in.	18in.
,, ,, under Tool-box ..	8in.	12in.	16in.
Price	£21 5s.	£31 5s.	£41 5s.
Weight	5½cwt.	10cwt.	14cwt.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

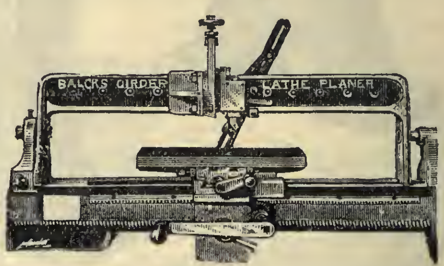
SMALL BENCH PLANER.



Will Plane Articles 14in. by $6\frac{1}{4}$in. wide, 5in. deep.
Table measures $14\frac{1}{2}$in. by 4in. **PRICE £6 10s.**

PATENT GIRDER LATHE PLANER.

Sole Makers: BRITANNIA CO.



IT is made to work upon the bed of a Lathe, and is secured in its place between the centres. A rack and pinion screwed under the top of lathe bed, and a crank handle, give the movement backward and forward. The saddle of a screw-cutting Lathe may in some cases be utilised.

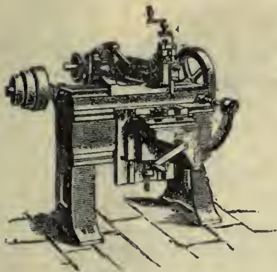
It has a self-acting feed motion, and some are fitted with two tool-boxes, so as to cut each way. Britannia Company fit Lathes to suit this Planer without extra cost, but ordinary Lathes require stronger racks, and extra is charged for fitting.

This tool had a very favourable notice in the *English Mechanic*, May 7th, 1886.

PRICE FROM £9.

A similar Planer, but fitted with an independent bed, which can be worked on any Bench or Table, price £10, is a most valuable addition to the workshop of the Mechanic.

IMPROVED SHAPING MACHINES.

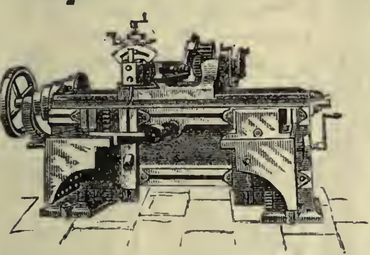


THESE are first-class tools, with longitudinal motion on the carriage, quick return by link motion. They are self-acting in circular and surfacing cuts. The tool-box is fitted with slides for vertical or angular cuts.

Parallel vice, overhead motion, and screw-keys, are included.

Telegraph Code	S4	Approximate Weight	14½cwt.
Length of Bed	3ft.	Price	£37 10s.
Stroke	6in. to 9in.	Extra per Foot of Bed	35s.
Traverse of Head	2ft. 4in.	Additional Table	£6
Additional Head	£13 10s.		

Improved Powerful Shaping Machines.



THESE machines are designed and constructed on the most approved principles, with the gearing for longitudinal traverse on the head or carriage, thus enabling the operator to set the cut without having to go to the end of bed, as heretofore. The above machines are made throughout with the greatest precision.

They are self-acting in horizontal and circular motion, the ram is indexed, and tool-box provided with slides for vertical or angular cuts, and worm and quadrant for internal curves. The tables are adjustable on the bed, and are raised and lowered by handle in front. Overhead motion and screw-keys complete.

They are fitted with quick return by link arrangements.

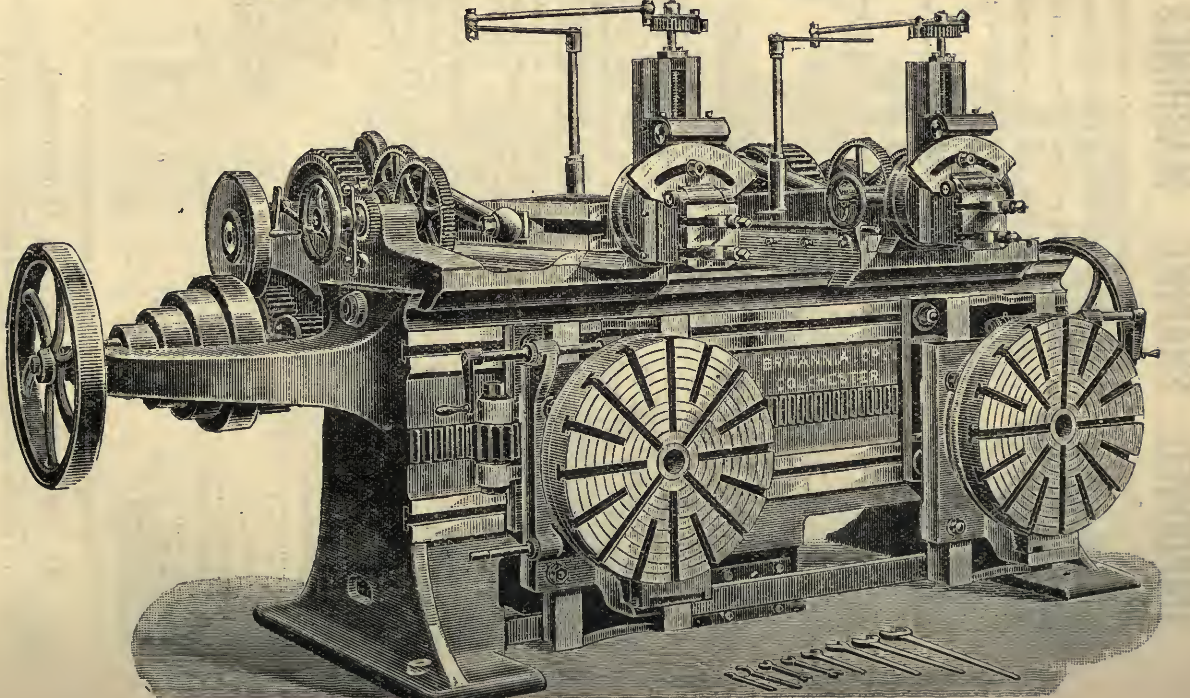
Telegraph Code	S 5	S 6	S 7
Length of Bed	4ft.	6ft.	8ft.
Stroke	13in.	14in.	18in.
Traverse of Head	2ft. 11in.	4ft. 6in.	5ft. 10in.
Size of Table	16 by 14¼	20½ by 14¼	23½ by 16¼
No. of Tables	1	2	2
Approximate Weight	25cwt.	36cwt.	60cwt.
Price	£60 0	£78 0	£105 0
Extra per Foot of Bed	£2 10	£4 0	£4 0
Additional Table	£8 0	£8 0	£12 0
Additional Head	£30 0	£30 0	£35 0

NOTE.—If made self-acting in vertical and angular cuts, extra, £

As made for the British Government.

BRITANNIA WORKS. COLCHESTER, ENGLAND.

BRITANNIA COMPANY'S
IMPROVED PATENTED SHAPING MACHINE.
As Made for Davey Paxman & Co.



THIS is a most handy Machine for general Engineer's or Machinist's shop, enabling a piece of work with several planed faces, as valve or bracket seatings, to be shaped on all sides at one setting, the immense advantage of which, by ensuring accuracy, and as an economiser of time and labour, will at once commend itself to every practical engineer.

The Machine is constructed with a strong circular work-table, having its face vertical, and with radial T slots for securely bolting the work to, which is capable of being easily rotated on its centre, and readily adjusted by slides both vertically and horizontally, so that any part of a piece of work fixed to it can be brought quickly under the operation of the tool on the ram-head.

The circular motion is by worm and wheel gearing (and at a small extra cost can be made self-acting if desired), by which means cylinder flanges, cross-heads, ends of connecting rods, and other circular work, can be done. The vertical adjustment is by worm or mitre gearing and elevating screw.

The Machine is fitted with the most recent improvements: the gearing is on the saddle, conveniently under the control of the operator, without having to move from his job, and is self-acting in both horizontal, vertical, and angular cuts.

The Machine illustrated is a Double Machine of large size, having a stroke of 24in., and is fitted with two heads and two tables, acting independently of each other; but the same patented arrangement can be fitted to any of our smaller Machines.

These Machines can also be supplied with a loose angle-bracket or table, to attach to the vertical-faced circular table, forming at once an ordinary shaping Machine, when circular or multiple-faced work is not required to be done.

SPECIFICATION OF DIMENSIONS, &c., OF THE MACHINE ILLUSTRATED.

Length of stroke, 24in.
Length of bed, 9ft.
Height of face of bed from floor, 4ft.
Width of face of bed, 2ft. 4in.
Traverse of heads, 3ft. 6in.
Vertical adjustment of work-table, 16in.
Diameter of circular work-table, 30in.

Pitch, Width on Face, and Diameters of Gearing:

First pair, 1¾in. by 4in.; pinion, 9in.; spur wheel, 18in.
Second do., 1½in. by 4⅜in.; pinion, 10½in.; spur wheel, 24in.
Pitch of feed-gearing, ½in. by 1½in. on face.
Extreme length of machine, 15ft.; width, 5ft. 4in.; height, 7ft.
Approximate weight, 11½ tons.

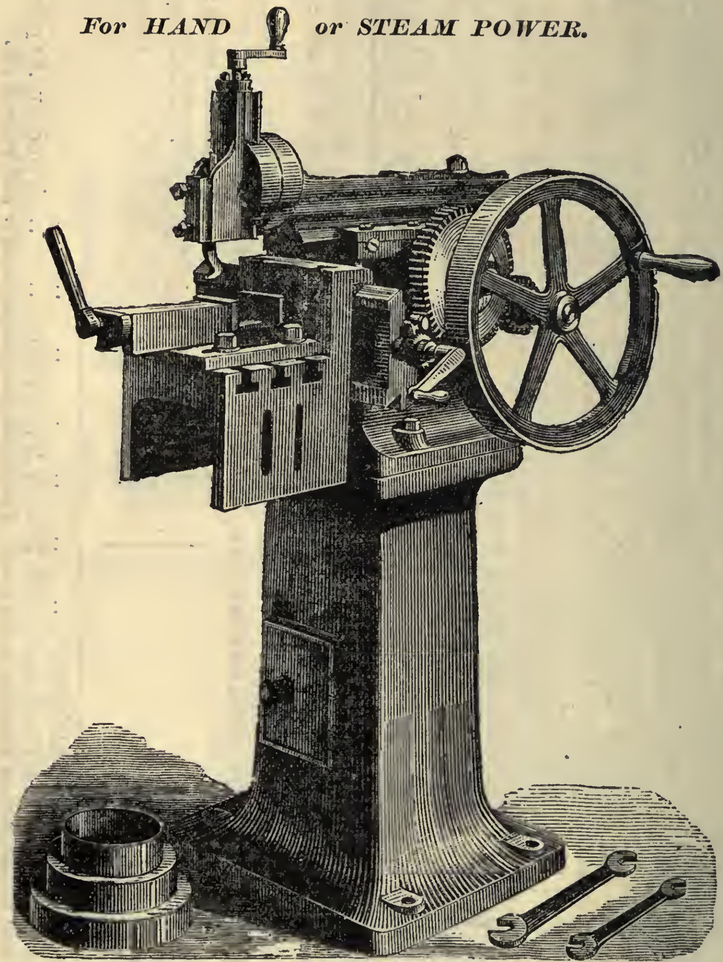
Price on Rails at Colchester .. ..

A Similar Machine, with One Head and with One or Two Tables .. .. Price on Application.

Above Tool is patented in England and Abroad. Information of Infringements will be paid for.

SELF-ACTING SHAPER,

For HAND or STEAM POWER.

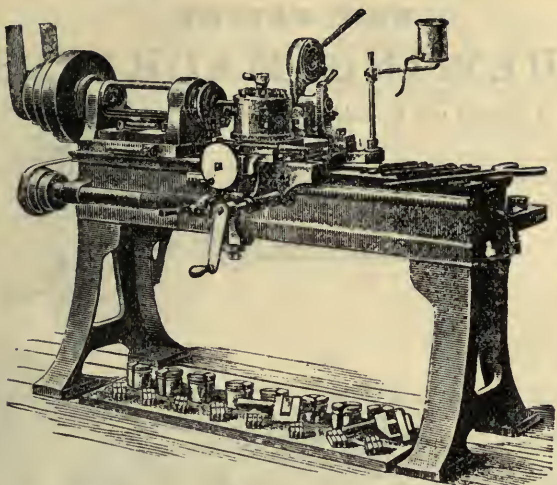


Has a traverse of 12in., and a 5in. stroke. Rising and falling table, fitted with T slots, and it is fitted with 5in. steel-jawed, parallel vice, with cone and fly-wheel, for hand and steam power. It has self-feeding motion, substantial hollow pedestal stand. Weight, about 5 cwt.

Price complete, £27 10s. If without pedestal to fix on bench, £19 10s.
Circular movement .. .. £2 10s. 14-inch Shaper £60

BRITANNIA WORKS, COLCHESTER, ENGLAND.

No. 27 STUD-CHASING LATHE.



THE above Illustration represents our improved hollow and open-sided Spindle Lathe with Capstan Rest, for **quickly** and **cheaply** producing screwed studs, joint pins, and small fittings of all kinds usually done in a Lathe. By means of this tool these can be made **uniformly,** far **quicker,** and by **cheap labour,** so that the tool soon **repays its cost.** It will turn, point, and chase studs at one operation by means of the Capstan rest.

The Headstock is constructed of two parts, accurately fitted to slide one over the other to adjust for taking up wear of spindle, the latter being made of steel, with hardened conical neck, with hole through its length to take long rods, and its sides open to enable headed bolts to be inserted for screwing, and its nose fitted with a coned chuck and gripping dies for 9 sizes of tools and rods, $\frac{1}{4}$in. to 1in. diam.

The saddle is arranged with transverse slide, carrying a **Capstan Tool-holder,** fitted with five tools, adapted for sliding, rounding points, surfacing, parting, &c.

On the saddle is mounted the screwing arrangement with die-box and adjustable dies for screwing $\frac{1}{4}$in., $\frac{5}{16}$in., $\frac{3}{8}$in., $\frac{7}{16}$in., $\frac{1}{2}$in., $\frac{5}{8}$in., $\frac{3}{4}$in., $\frac{7}{8}$in., and 1in., and hinged to throw back out of the way when not screwing.

☞ The saddle is also fitted with **quick traverse** by rack and pinion, also **self-acting traverse** by fine-thread leading screw with convenient disengaging nut.

The bed is of trough section, to catch the soap-and-water, and constructed to conveniently draw it off.

The whole is of best materials and workmanship, and of the following dimensions. Complete overhead motion with reversing motion, soapsud-can and stand, screw keys, spanners, &c., are included in the price.

Height of centre .... 7 inches.
Driving cone .... 4 speeds, $2\frac{3}{4}$ inches wide.
Feed cones.......................... 3 speeds, $1\frac{1}{2}$ inches wide.
Length and width of bed .... 5 feet by $12\frac{1}{2}$ inches.
Largest ...... 13 inches diameter. Smallest ...... 7 inches.

PRICE Complete ....

BRITANNIA COMPANY, COLCHESTER.

London Show-rooms—100, Houndsditch.

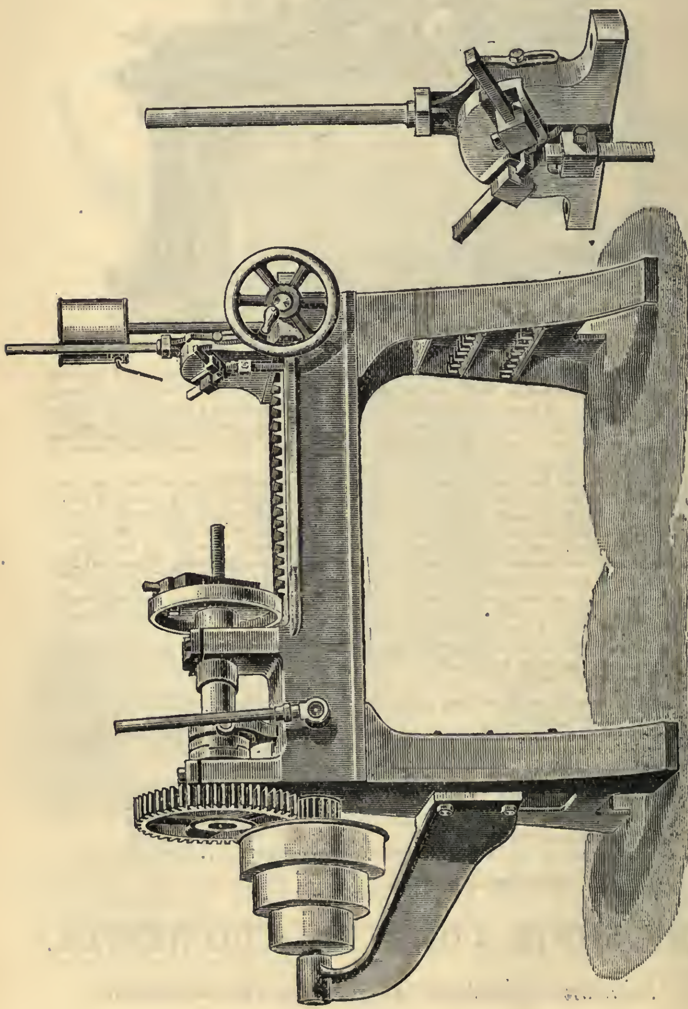
☛ WORTH ATTENTION.

BRITANNIA COMPANY'S

NEW PATENT

SCREWING MACHINES,

A Reward will be paid for information of Infringers.



(For description, see next page.)

New Patent Screwing Machine,

AS ILLUSTRATED ON PRECEDING PAGE.

THESE Machines are constructed on improved and very simple principles, greatly advantageous to users in point of economy, both in working and maintaining in repair.

The headstock is constructed with a hollow spindle, to take rods or tubes of any length, and with a self-centreing die chuck for gripping rods, tubes, or bolt heads. A clutch and lever enables the machine to be started and stopped instantly, and independently of the counter-shaft.

The spindle is driven by a 3-speed cone pulley and powerful gearing.

The Bed is machine-planed, of trough section, to catch the soap-and-water used in screwing, and is fitted with a tap to draw off.

Fitted to the bed is a saddle to slide along, and, moved by racks and pinions and hand wheel, carries the Screwing Head. This is fitted with three tool-boxes, carrying tools similar to ordinary chasers, and so constructed as to be held firmly in position by one set screw to each. These are closed and opened by lever and eccentric cam, and the top face of the screwing head is graduated, and fitted with a stop to adjust the depth of cut.

The **important feature** of this screwing head is the simplicity of the dies, which are simply pieces of steel cut off the bar, put into the tool-holder, and secured by set screws. In this machine they can then be cut up by the master tap and hardened, and are finished ready for use; **no expensive fitting** for length or in any other respect is needed, but treated as an ordinary turning tool is put in the slide rest of a lathe.

The advantages of this machine may be thus summarised:

The thread is completed at a single cut.

The Screwing Dies are as easily sharpened by grinding the face as ordinary lathe chasers, and hence do ten or twelve times the work of the many complicated systems in the market.

The Screwing Dies when at last fairly worn out, are cheaply replaced by any ordinary mechanic, by merely cutting off from a bar of steel, fixing in their places by set screws as an ordinary lathe tool, and cutting the thread by the master tap supplied, in their own machine.

The method of holding the Dies is so arranged that the strain comes on the rest or holder, instead of upon the Dies, which thus endure so much more work.

The arrangement of the Screwing Head and Dies enables the cutting edges to be plainly seen, and these are clear for work, and cannot get choked by cuttings.

The Clutch arrangement enables the machine to be stopped instantly, in case of accident or necessity.

The whole is so simple that there is nothing to get out of order by ordinary fair use, and if breakage occurs by any mishap, parts can be easily replaced.

Each machine is sent out complete with Master Taps and Dies for ½in., ⅝in., ¾in., ⅞in., and 1in.; Reversing Overhead Motion. Standards fitted with Shelves for Dies and Taps, Screw Keys, &c., &c.

DIMENSIONS:

Bed, 4ft. long, 10in. on face, 6in. deep; cone pulley, 3 speeds, 3in. wide—largest, 12in. diameter; gearing, ¾in. pitch, 2in. face; spur wheel, 12½in. diameter, and pinion 4½in.; spindle bored with 1¾in. hole.

Approximate Weight, 8cwt. Price complete, £35.

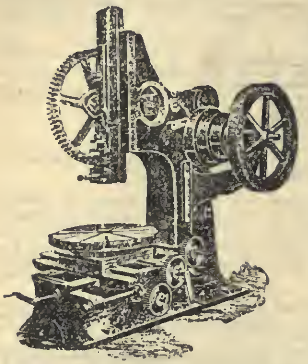
The Patented Screwing Head can be fixed to existing machines, or to the saddles of ordinary lathes.

Estimates on application. Other sizes in preparation.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

IMPROVED

SLOTTING · MACHINE.



THE annexed engraving illustrates a machine with the following advantages:—

The table cants over for cutting taper key-ways, &c., &c.

It has longitudinal traverse and circular motion; each can be disengaged independently, and are self-acting.

The ram is made with long bearings and compensation balance lever, which acts in any position with the ram.

The end of the lever is slotted, and carries a sliding block from crank pin, which gives an adjustable stroke and quick return.

The link is fixed at the extreme end of lever of ram, thus giving a direct thrust without side strain, and so avoiding considerable wear and friction.

The bearings of the ram are long, thus ensuring firmness and accuracy of stroke.

A long or short stroke can be given, either close to the table or at the extreme end.

The adjusting screw for regulating height of ram is in front, but all movements of tables and slides are on the side where the man stands, thus saving much inconvenience, all being within reach of the workman. This is a contrast to other similar machines, which require the man to mount the table and to move from one side of the machine to the other to adjust the various movements.

The cone is *parallel* to the shafting, and enables the machine to be fixed near the shafting, and not at right angles. It is fitted with top-driving apparatus, screw-keys, &c.

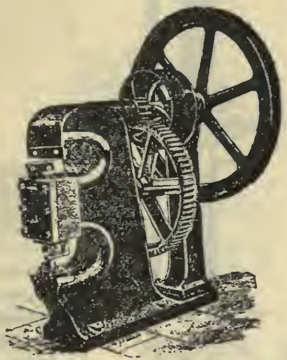
Telegraph Code		S1	S2	S3
Length of Stroke		12in.	14in.	18in.
To Admit	In Diameter	4ft.	5ft.	6ft.
	In Depth	1ft. 8in.	2ft. 4in.	3ft. 0in.
Traverse of Table Slides	Longitudinally	2ft. 4in.	3ft. 0in.	3ft. 6in.
	Transverse	2ft. 2in.	2ft. 6in.	3ft. 0in.
Approximate Weight		55cwt.	70cwt.	140cwt.
Price				

Prices are subject to alteration without notice.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

SINGLE-ENDED

PUNCHING & SHEARING MACHINE.



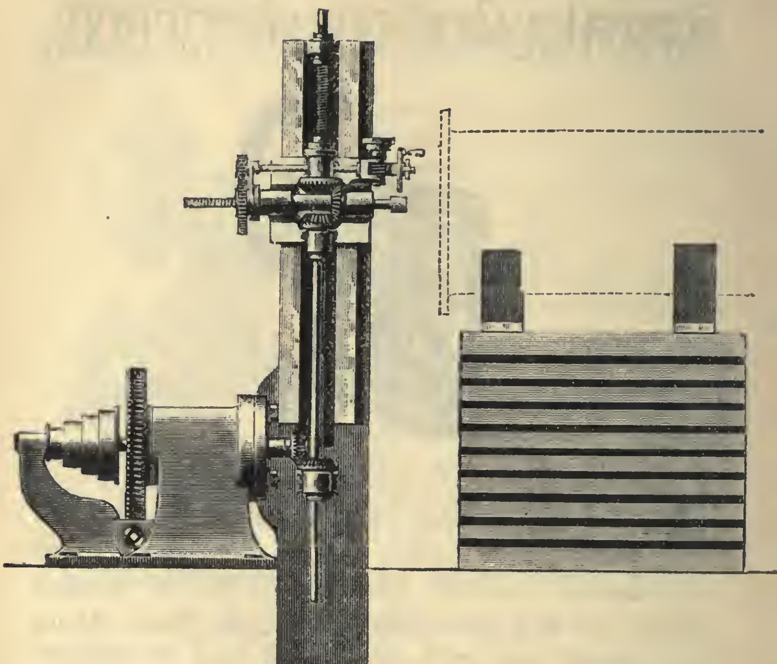
SINGLE-ENDED Punching and Shearing, to punch below and shear above, shears being placed at an angle so long bars can be cross-cut. These machines are fitted with steel or wrought-iron eccentric shafts, fast and loose pulleys, heavy fly-wheel, strong and powerful gear, with standard at back for supporting fly-wheel shaft, complete with one punch and die one pair of shear blades, and stripper. Similar machines in design, made to punch only, or to shear only, for special work.

		No. 1.	**No. 2.**	**No. 3.**
Telegraph Code		PS 1	PS 2	PS 3
To Punch in Diameter		$\frac{3}{4}$in.	$\frac{3}{4}$in.	$\frac{3}{4}$in.
Thickness of Plate to Punch		$\frac{1}{2}$in.	$\frac{5}{8}$in.	$\frac{3}{4}$in.
Thickness of Plate to Shear ..		$\frac{1}{2}$in.	$\frac{5}{8}$in.	$\frac{3}{4}$in.
Depth of Gap	To Shear ...	11in.	9in.	11in.
	To Punch ...	10in.	12in.	12in.
Approximate Weight		24cwt.	36cwt.	40cwt.
Price				
Less if without wheels				

FOR LARGER SIZES, APPLY FOR QUOTATIONS.

Similar Machines as made for the British Government.

The Britannia Co.'s Horizontal Radial Drill.



A VERY handy tool for drilling flanges at ends of long pipes, or holes in any position in the vertical sides of machines or machine frames, as spindle holes, &c., which can all be done at once setting by rotating the arm and moving the saddle along it. The Radial Arm is counterbalanced, and is rotated by worm and wheel gearing to any position, and would revolve through an entire circle but for the floor.

The feed is self-acting, with three changes of speed, and hand feed is also provided.

The Table for holding the work is truly planed, and has T slots on top and one side, and carries a pair of V blocks for holding pipes up to 24in. diameter.

DIMENSIONS.

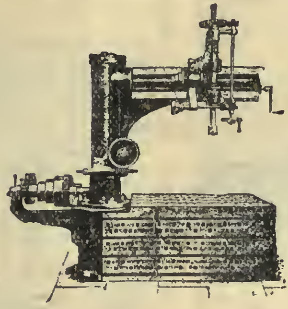
Radial Arm is 5ft. long from centre; Traverse of Saddle on it is 3ft. 8in.; will drill a hole 1½in. in diameter by 9in. deep, and 4ft. 6in. from centre; Steel Spindle is 1¾in. diameter; Vertical Driving Shaft, 1¾in. diameter; Bevel and Mitre Gearing, ¾in. pitch; Worm Wheel, 22in. diameter and ⅞in. pitch; Cone Pulley has 4 speeds 2½in. wide (largest speed, 10in. diameter; smallest, 4½in.); approximate total weight, 2½ tons; table is 3ft. high by 3ft. wide by 4ft. long.

Price, complete, with Table and V *Blocks, as illustrated ...*

Price of Drill only, without Table and Blocks ....

IMPROVED

Radial · Drilling · Machine.

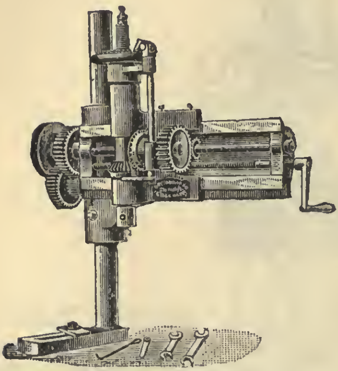


THE above engraving represents our 4ft. 6in. Radial Machine from new and improved designs, dispensing with overhanging top shaft, which allows of arm to be worked in a complete radius, and driven from any position. The base-plate, which is very strong, is 6ft. 2in. long, 3ft. wide, by 27½in. deep, with through and T slots planed out of solid. The machine is supplied with overhead driving motion, handles, and screw-keys complete.

	No. 1.	No. 2.
Telegraph Code	D 1	D 2
Radius	4ft. 6in.	6ft.
Arm to rise and lower	1ft. 4in.	2ft. 6in.
Longitudinal traverse of head on arm	3ft.	4ft. 6in.
Will admit in depth to foundation-plate	4ft.	5ft.
Size of spindle	2½in.	2¾in.
Approximate weight	50cwt.	90cwt.
Price		

No. 2 has a lower Bed-plate, for heavier work, and is a much larger Machine than above Illustrated.

NEW PORTABLE RADIAL
DRILLING MACHINE, No. 6.



THIS machine has been specially designed to take the place of the old ratchet-brace, and is adapted for bolting to locomotive frame plates or similar work for drilling and rimering holes up to 1½in. diameter by 4in. deep.

It consists of a strong steel tubular pillar, forged on to a wrought-iron, slotted foot, and is capable of being turned to any desired angle, and when bolted in position is capable of drilling all holes within a radius of 18in. from centre of pillar. The spindle is of steel, 1½in. in diameter, driven by strong gearing, and arranged to drive from either a swinging countershaft, as used in locomotive-shops, or from a fixed countershaft, if desired. The spindle has a variable self-acting and also hand feed. The Drill will rise and fall on the pillar through a range of 18in. The bevel and driving gear is ⅝in. pitch. Approximate weight, 4cwt.

Price, complete, if for swinging countershaft...	£22	0	0
,, ,, if for fixed countershaft	27	0	0
Countershaft to suit, if required	2	10	0

A Box Foundation-Plate,

Prepared to receive the wrought-iron, slotted foot of the Drill, and accurately planed on top and one side, with planed T slots for bolting work to, can also be supplied, thus enabling the Drill to be used (when desired) as a small but complete fixed Radial Drill.

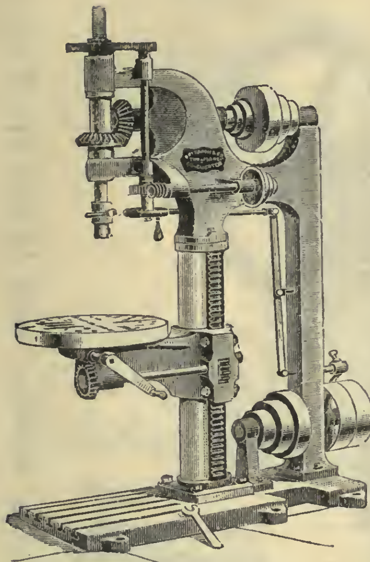
Dimensions of base, 2ft. 6in. by 1ft. 6in. by 12in. high.

Approximate weight of base, 4cwt.

Price extra of base £6 10 0

BRITANNIA WORKS, COLCHESTER, ENGLAND.

No. 1 STRONG PILLAR DRILLING MACHINE.



THIS is a very useful machine, strongly built for its size. The main body is a box-casting, faced and truly fitted on to a turned pillar, and securely bolted on to a planed foundation-plate, having T slots for bolting large work to. The turned circular table is made to swivel on its centre, and to swing around the turned pillar, and is raised and lowered by rack and pinion with worm gearing.

The driving apparatus is self-contained, making the machine very compact.

The steel spindle is driven by strong bevel gear, and has both hand and self-acting feed by worm wheel and screw, and friction cone.

All motions are arranged so as to be conveniently accessible to the operator, and all material and workmanship are of the best.

This is very superior to the Drills generally sold, both in finish, accuracy, and handiness.

DIMENSIONS, &c.

Diameter of Steel Spindle ...	$1\frac{3}{4}$in.	Cone Pulley, 3 speeds, width	$2\frac{1}{4}$in.
Drills up to...	2in.	Diameter of largest is... ...	9in.
Drills in depth	7in.	Diameter of Pillar	6in.
Admits in diameter	24in.	Pitch of Bevel Gear	$\frac{3}{4}$in.
Diameter of Table	20in.	Pitch of Rack and Pinion...	$\frac{3}{4}$in.
Table rises and falls	27in.	Total height	6ft. 6in.

Approximate weight... ... ... 12cwt.

Price complete, £26 10s., or with Double-gearing, £31.

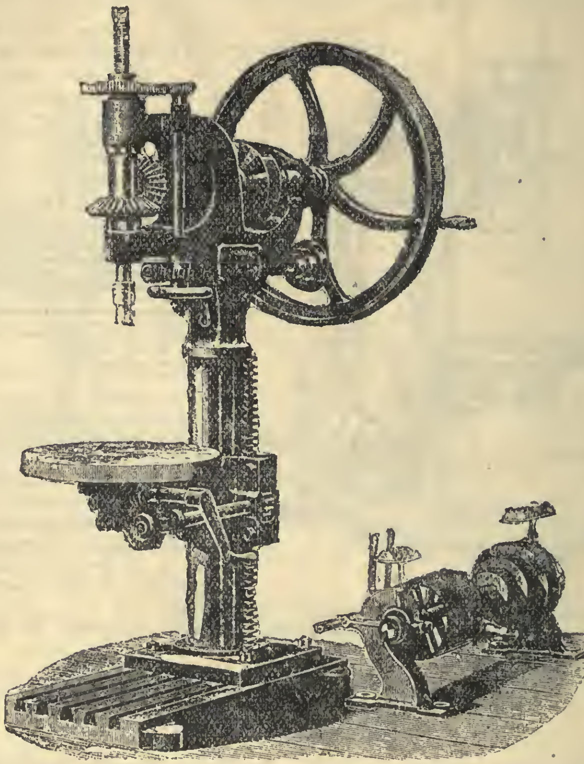
For Larger Sizes, Send for Quotations.

As Supplied to the British Government.

Nos. 2 & 3 STRONG SINGLE GEAR

Pillar Drilling Machines for Hand & Power.

AS SUPPLIED TO THE BRITISH GOVERNMENT.



Multiple Drilling Machines made to Suit any Work.

THESE machines are of new design, and embody all the latest improvements in small Drills. They have strong box-casting for the body pillar, and base in one piece, the pillar being turned bright, and the base firmly bolted on to a planed foundation plate with T slots for larger work. The spindle is of steel, driven by strong bevel gearing; hand and self-acting feed by worm wheel and screw, engaging by friction cone. The circular work-table will swivel on its centre, and also swing entirely round the pillar and is raised and lowered by worm and wheel, with rack and pinion gearing. The fly-wheel has truly turned bright rim, and fitted with wood handle for driving by hand when that is desired. A complete top driving apparatus for steam power, and the neccssary keys and wrenches, are included in the price.

They are of the best materials and workmanship.

DIMENSIONS, &c.

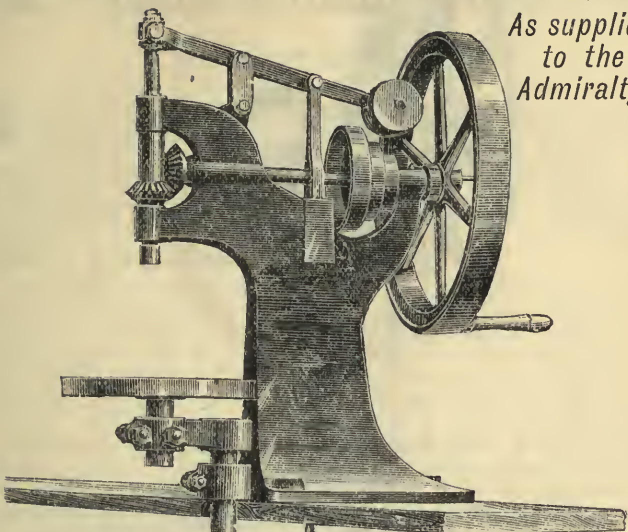
	No. 2	No. 3
Telegraph Code	D 4	D 5
Steel Spindle, Diameter	1½in.	1⅜in.
Drill up to	1½in.	1¼in.
Drill in depth	7in.	6in.
To admit in Diameter	24in.	24in.
Diameter of Table	20in.	20in.
Table rises and falls	21in.	18in.

	No. 2	No. 3
Cone Pulley, 3 speeds, width	2¼in.	2in.
Diameter of largest speed	9in.	7½in.
Diameter of Pillar	6in.	5in.
Pitch of Bevel Gearing	¾in.	⅝in.
Pitch of Rack and Pinion	⅝in.	¾in.
Total Height	5ft 6in	4ft 11in
Approximate Weight	11cwt.	8½cwt.
Price, complete	£25	£22 10s.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

Britannia Compy.'s No. 4 Bench Drill.

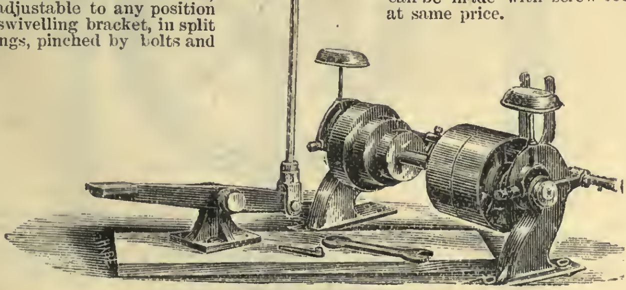
As supplied to the Admiralty.



This is a very handy little drill for both hand and power. It is constructed with a strong box casting for the main body, with shaft holes truly bored, and with steel spindle fitted with mitre gearing. A turned circular table to rise and fall, and adjustable to any position by a swivelling bracket, in split bearings, pinched by bolts and nuts.

It has a turned 3-speed cone pulley, turned heavy flywheel, and wood handle.

The feed is by treadle motion and balance lever, leaving both hands of the operator at liberty for work. But if preferred, it can be made with screw feed, at same price.

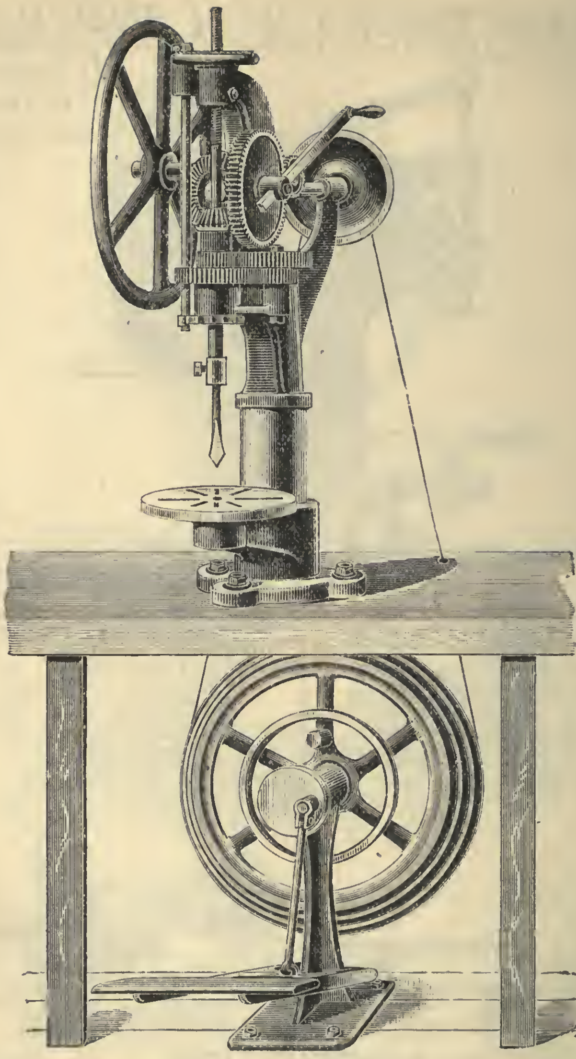


SPECIFICATION

Steel Spindle ....1¼in. diameter
Cone Pulley, 3 speeds ....1½in. wide
Diameters.. Largest 9in., Smallest 5in.
Circular Table..........16½in. diameter.
Distance between Spindle & Table 12in.
Will take in a diameter of ......17½in.
,, Drill a hole ¾in. dia. by 4½in. deep.

Base of Body measures ....18in. by 14in.
Flywheel ....26in. diameter, 2¾in. face.
Total ht. from bench to top of Drill 40in.
Approximate Weight .... 4¾cwt.
Price, complete, including countershaft for power, **£12.**
With hardened steel spindles, £16 10s.

BRITANNIA WORKS, COLCHESTER, ENGLAND.



No. 5 BENCH DRILLING MACHINE.

No. 5 BENCH DRILLING MACHINE.

IMPROVED STYLE.

THIS is a handy Drill for light work, made to drive by hand or treadle, or by both, and can also be driven by power if desired. It is constructed with a web-section body, turned to fit on to and swivel around a stiff turned pillar, secured by a nut at any angle, and by loosening which the drill can be brought to any position in its radius, and is thus **very handy for drilling holes in large objects.**

The pillar is cast in one, with a strong foot, to bolt on to the bench, and carries a bracket which swivels entirely round it, carrying a circular work-plate, which also swivels on its own centre, giving every facility for adjusting the work bolted to it under the Drill. It has two driving shafts, that for the treadle or power running to the back, and that for hand motion to the right side, and these drive the spindle by bevel and spur gearing. **It is constructed with a specially ingenious contrivance of spur gearing in combination with a fly-wheel, which gives immense impetus to the motion, and greatly facilitates the work.** It has also **single and double gearing for small and large holes,** and has both self-acting and hand feed.

The treadle driving gear is made independent of the machine, to fix under the bench, the wheel having four speeds to drive the speed-cone fitted to the driving shaft, thus giving with the double gearing eight changes of speed.

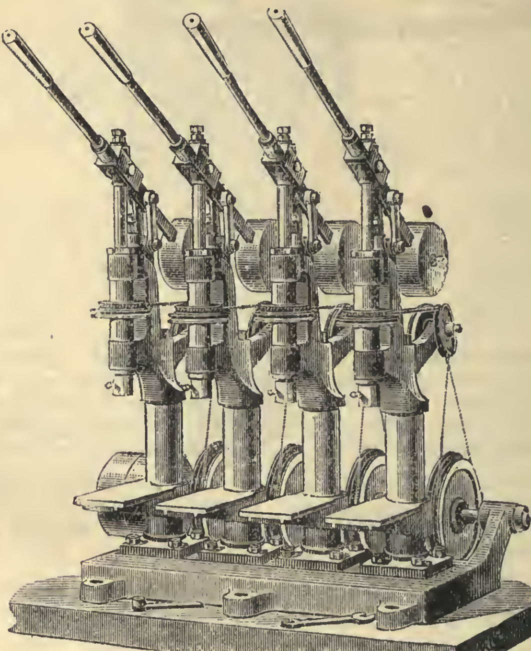
By the combination above named this Drill is more effective than much larger tools of the usual pattern.

DIMENSIONS AND PRICES.

Diameter of spindle ...	$\frac{7}{8}$in.
Drilling up to $\frac{3}{4}$in. diameter by 5in. deep.	
Pillar, 4in. diameter by 11in. high.	
Distance from Drill-point to pillar ...	9in.
Diameter of driving shaft ...	$\frac{7}{8}$in.
Diameter of fly-wheel ...	18in.
Diameter of driving wheel of treadle motion ...	20in.
Diameter of circular work-table ...	10in.
Table will rise and fall on pillar ...	$6\frac{1}{2}$in.
Approximate weight ...	$2\frac{1}{2}$cwt.
Price complete, as Hand Drill only ...	**£6 10 0**
Price complete, as Hand and Treadle Drill ...	**8 0 0**
Price of top driving apparatus for power driving, if desired...	**2 0 0**

BRITANNIA COMPANY'S

Electrical Engineers' Drills.



THE above illustration represents a gang of four quick-speed drilling machines, mounted on a cast-iron base, for rapidly drilling small holes of equal or varying sizes, or countersinking, recessing, &c.

They are driven by countershaft at back, fitted with one pair of fast and loose pulleys, and a cone pulley for each drill, and are designed to be driven by power.

They are made with steel spindles, running in hard steel bearings, and are fed by hand lever and link motion, with balance weight to bring up the spindle, the latter having a steel swivel at top. They have turned pillars, with tables to rise and fall, or swivel around.

DIMENSIONS, PRICE, &c.

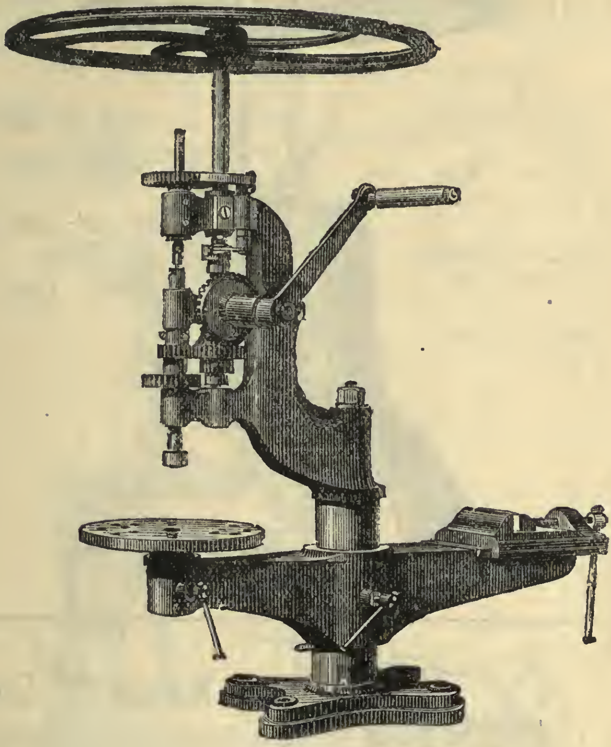
To drill holes up to $\frac{3}{8}$in. diameter, and $3\frac{1}{2}$in. deep
Diameter of steel spindle, $\frac{7}{8}$in.
Turned pillar, $2\frac{1}{2}$in. diameter by 9in. high.
Table rises and falls $6\frac{1}{2}$in.
Size of cast-iron base for four drills, $26\frac{1}{2}$in. by 10in.
Total height from base to lever, 26in.

Price for Gang of Four Drills, as Illustration, £37 10s.

Single Drills, to work by foot power, 135s.;

Foot and Steam, 150s.

No. 410 and 420 DRILL.



These Drills have Double Gearing, Fast and Slow Feed Motion, Fast and Loose Pulleys, or 3-speed Cone on Side, Circular Table, Parallel Vice to swing round under Drill.

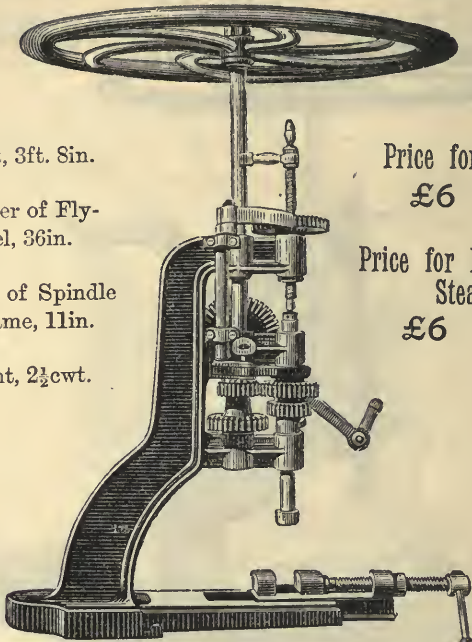
No. 410 Drills Holes $\frac{7}{8}$in.

Nos. of Machines.	To Drill Holes diam.	Diam. of Fly-wheel.	Will take in diam.	Height.	Approximate Weight.	Price for Hand only.	Hand and Steam.
410	$\frac{7}{8}$ inch	30 inches	24 inches	4ft. 4in.	3 cwt.	£7 10s.	£8
420	1 inch	32 inches	26 inches	4ft. 6in.	$3\frac{1}{2}$ cwt.	£8 15s.	£9 5s.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

No. 110 DRILL.

Will Drill Holes up to 1¼in.



Height, 3ft. 8in.

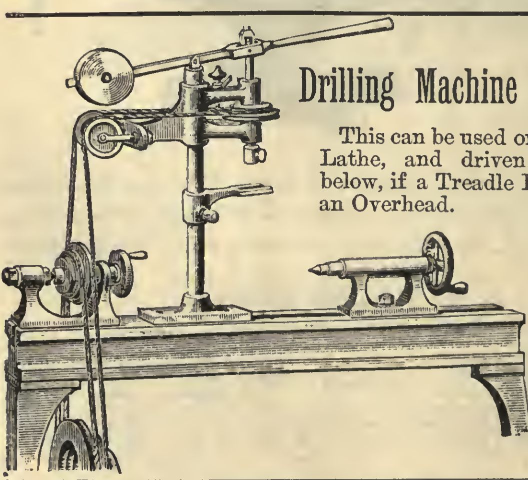
Diameter of Fly-wheel, 36in.

Distance of Spindle to Frame, 11in.

Weight, 2½cwt.

Price for Hand,
£6 5s.

Price for Hand and Steam,
£6 15s.



Drilling Machine for Lathe.

This can be used on any ordinary Lathe, and driven either from below, if a Treadle Lathe, or from an Overhead.

This is a useful Tool.

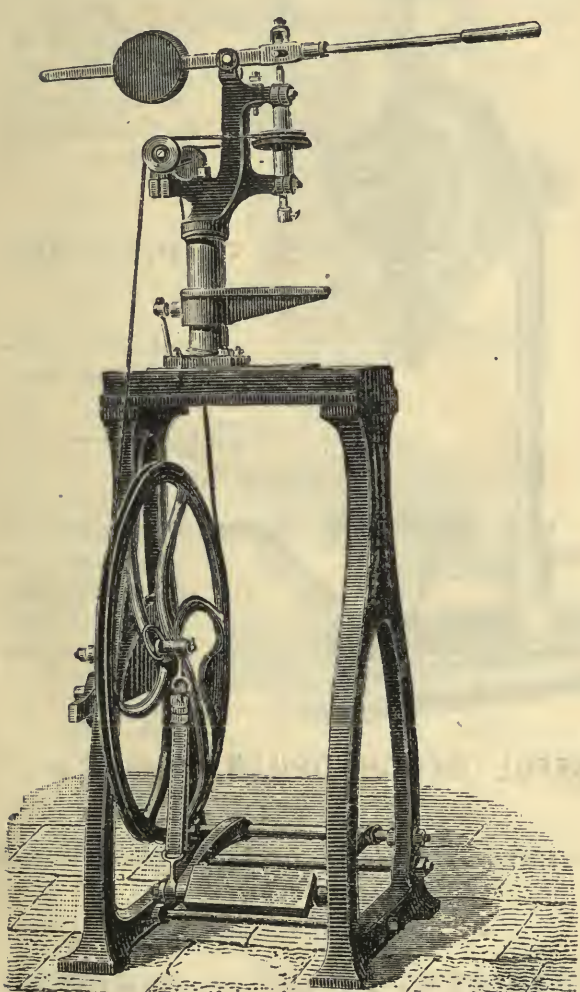
PRICE

£

No. 10

Lever Treadle Drilling Machine.

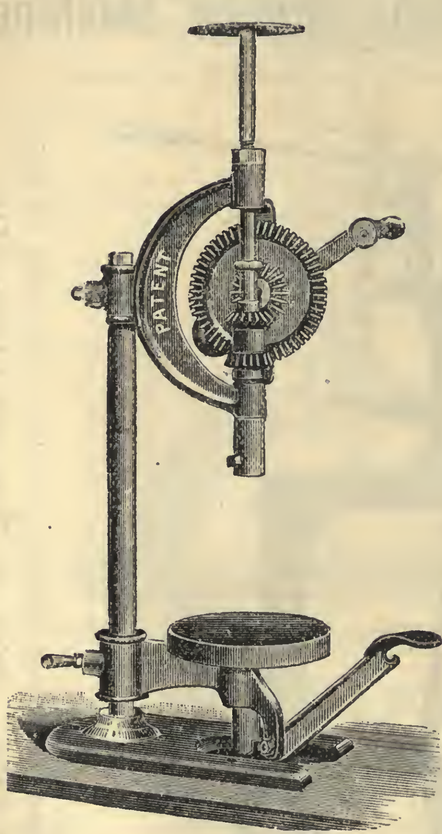
To Drill holes up to $\frac{5}{16}$in. diameter by foot or steam.



Specialty for drilling small holes at high speed; well fitted; suitable for bicycle makers and others.

Price for Foot, 135s. Price for Foot and Steam, 150s.

BENCH DRILL.



Can also be used as a BRACE by taking it off the Pillar. By pressing the Lever at foot the Table is raised.

Price 30s.

"A very useful tool in any shop."

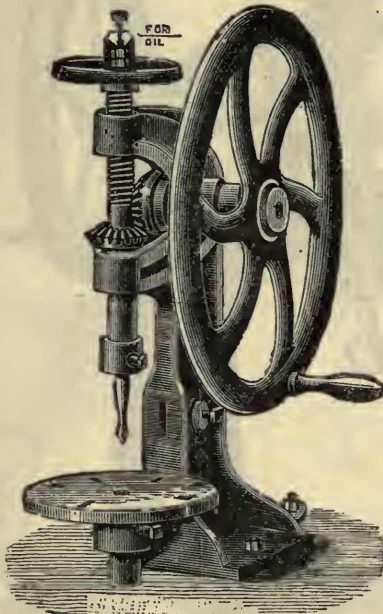
BRITANNIA CO. manufacture a large number of Drilling Machines, for Hand or Steam Power. (*See Catalogue.*)

USEFUL BENCH DRILLS, from 25s.

Special attention is requested to the Quality of our Drills.

BRITANNIA CO., COLCHESTER.

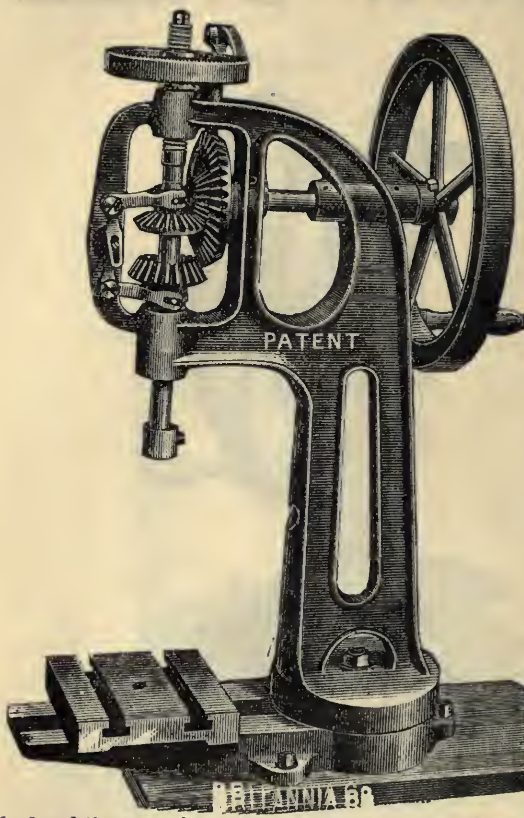
BENCH DRILL.



SIZES—

Weight	25lbs.	...	Drill $\frac{5}{8}$ holes		...	30/-
„	80lbs.	...	„ $\frac{3}{4}$	„	...	45/-
„	150lbs.	...	„ $1\frac{1}{2}$	„	...	80/-

No. 2. "Union" Patent Bench Drill.



THIS Tool has two rates of speed obtained by means of two sets of bevel wheels, the pinions of which are caused to be in or out of gear alternately by turning the eccentric lever controlling them.

The table is carried on a slotted arm and can be revolved so that any part of the table can be bronght under the point of the drill. The standard is made to move radially on the base. These movements give great scope and convenience, and will be fonnd valuable in use.

It is self-acting in its feed and the general formation is rigid, and the workmanship and material good.

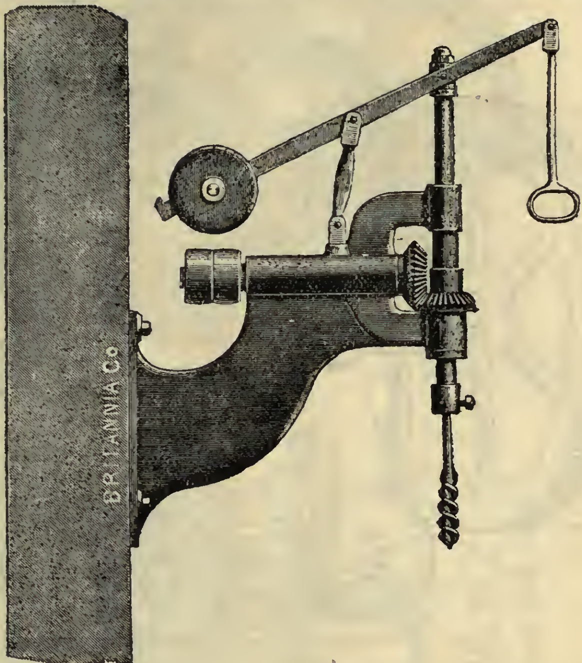
It is also made single speed, with or without self-acting feed, and a drilling vice is supplied when desired. Will drill up to $\frac{7}{8}$in., take in 19½in. diameter, and is 2ft. 7in. high. Weight abont 1 cwt.

PRICES.

		£	s.	d.
Double Speed, Self-Acting Feed	...	**4**	**5**	**0**
Single „ „ „	...	**3**	**17**	**6**
„ „ (not Self-Acting)	...	**3**	**15**	**0**
Vice (large)	...	**1**	**0**	**0**
„ (small)	...	**0**	**12**	**6**

BRITANNIA WORKS, COLCHESTER, ENGLAND.

WALL BORING MACHINE.



The above machine has been specially designed to meet the demand for a cheap Boring Machine, for the use of builders, cabinet makers, &c., &c.

It is capable of boring holes in all kinds of hard or soft wood with efficiency and despatch. Where room is an object this machine will be found to be very convenient on account of the very small space it requires.

The boring spindle revolves in a strong cast iron frame, firmly bolted to a wall, and is counter-balanced by weight and lever.

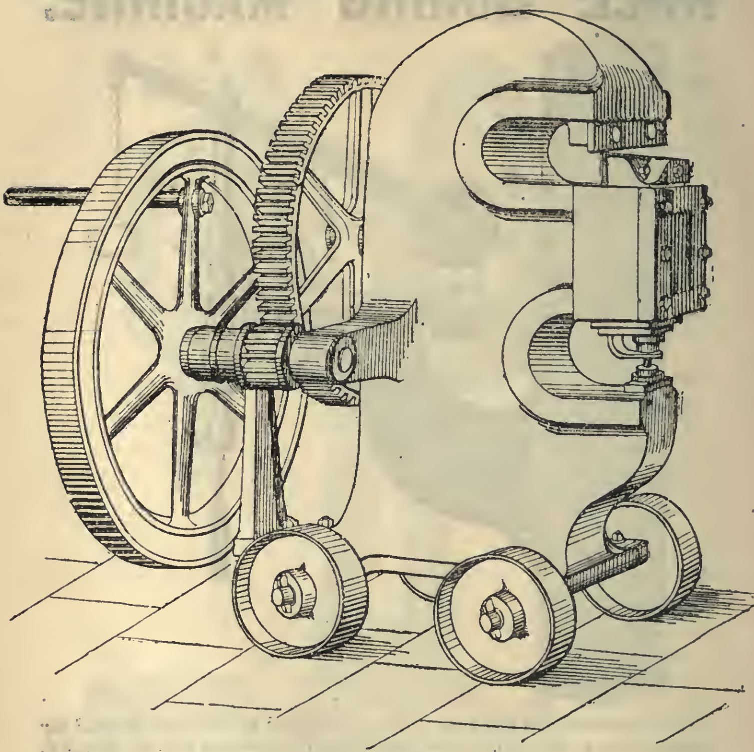
It is driven by bevel tooth gear, and fast and loose pulleys, and the spindle is raised or lowered to suit various depths of work required by means of wrought handle attached to weight lever, as shown in front of machine.

Size ....to bore holes up to 2in. diameter and 8in. deep.
Approximate Weight..2 cwt.
Average Power required ....½-horse.
Size of Driving Pulleys ....5in. by 2½in.
Speed of Driving Pulleys ....500 Revolutions.

Price ....£6 10s.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

IMPROVED PUNCHING & SHEARING MACHINES.



No. 35.

THE above handy portable Punching and Shearing Machine, of improved construction, powerfully geared, single ended, shearing above, and punching below. The body is a strong box casting, with thick beads round the gullets, and fitted with slide, accurately scraped in, carrying the shear blade and punch, the former being set at an angle for shearing long bars. (We have improved the design of this.)

Steel main shaft, strong gearing, heavy turned flywheel, with handle for working by hand; the machine is mounted on four strong wheels for moving about the yard, or can be made with fast and loose pulleys for power driving, and without transport wheels if desired.

No. 35 has Gearing 3¾in. face by 1¼in. pitch; large wheel 32in. diameter; pinion 6in. diameter; flywheel 48in. diameter; fast and loose pulleys 15½in. diameter, 3in. face.

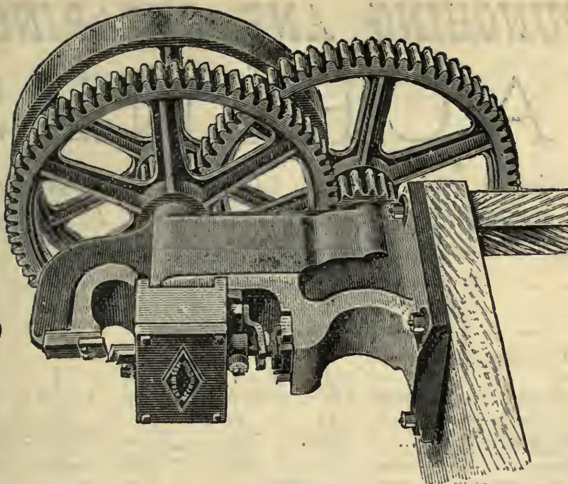
No.		PS35	PS2	PS3	No	PS35	PS2	PS3
To punch in diameter		¾in.	¾in.	⅞in.	Approximate weight	24cwt.	36cwt.	40cwt.
Thickness of plate	to punch	½in.	⅝in.	¾in.	Price as above	£27		
	o shear	½in.	⅝in.	⅞in.	Price if for power also	£28 10s.	£36	£43
Depth of gullets	to punch	10in.	12in.	12in.	Less if without wheels	£1		
	to shear	11in.	9in.	11in.				

We have recently designed an improvement on above design.

AS MADE FOR THE BRITISH GOVERNMENT.

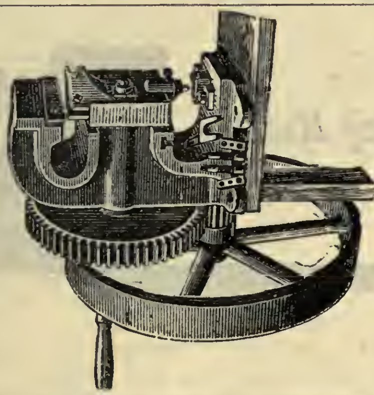
BRITANNIA WORKS, COLCHESTER, ENGLAND.

Shearing and Punching Machines.



Will shear $\frac{3}{8}$in. iron, punch $\frac{3}{8}$in. holes.

Price £18.

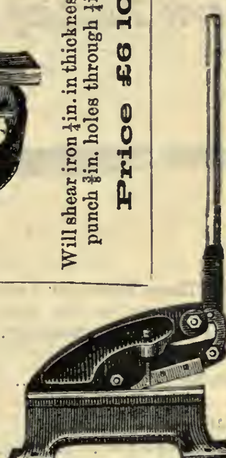


Will shear iron $\frac{1}{4}$in. in thickness, and will punch $\frac{3}{8}$in. holes through $\frac{1}{4}$in. iron.

Price £6 10s.

No. 11.

LEVER SHEARING MACHINE.



To cut sheet iron up to $\frac{1}{8}$in. Round or square bars up to $\frac{3}{16}$in.

Has a solid casting, and guide; will cut through the middle of sheet iron.

Weight	...	60lb.	Length of Blades	...	6in.
Price	...	**45/-.**	Extra Shears	...	**7/-.**

BRITANNIA WORKS, COLCHESTER, ENGLAND.

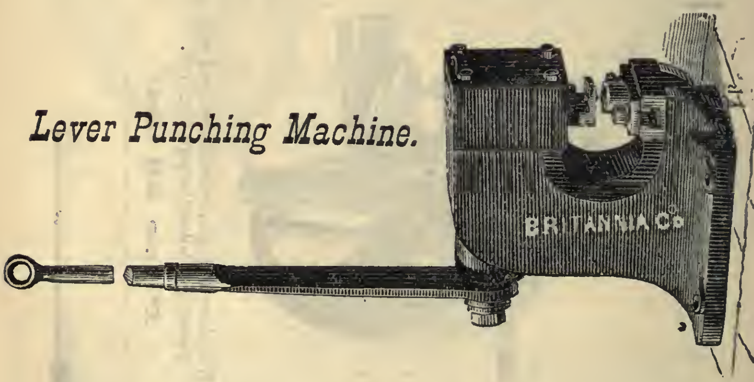
PUNCHING AND SHEARING

MACHINES,

Of new design with lever at back. Box casting for body. To punch at bottom and shear at top. In five sizes as under—

Number	21	22	23	24	25
Largest Diameter to punch...	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{2}$
Thickness „ ...	$\frac{3}{16}$	$\frac{1}{2}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{2}$
Width and thickness to shear	$\frac{3}{4}$ by $\frac{3}{16}$	$\frac{3}{4}$ by $\frac{1}{4}$	1 by $\frac{5}{16}$	$1\frac{3}{16}$ by $\frac{5}{8}$	$1\frac{3}{8}$ by $\frac{1}{2}$
Distance from body to punch	$1\frac{1}{2}$	$2\frac{1}{2}$	3	$3\frac{1}{8}$	$3\frac{1}{2}$
Approximate weight..........	28lbs.	50lbs.	90lbs.	154lbs.	190lbs.
Price........................	35/-	40/-	60/-	75/-	100/-

Lever Punching Machine.



These Machines have strong box castings, cast steel spindle, powerfu eccentric lever on the side, punch and die set to punch angle and ⌶ iron. Works easily and efficiently.

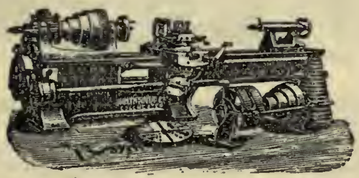
Number of Machines........................	1	2	3	4
Will punch diameter........................	$\frac{3}{8}$in.	$\frac{1}{2}$in.	$\frac{5}{8}$in.	$\frac{1}{4}$in.
Through plates	$\frac{1}{4}$in.	$\frac{3}{8}$in.	$\frac{3}{8}$in.	$\frac{1}{8}$in.
Depth of gap	3in.	4in.	$4\frac{1}{2}$in.	$1\frac{1}{2}$in.
Weight	1cwt.	2cwt.	3cwt.	28lb.
Price	85/-	120/-		35/-

No. 4—A speciality for Hoop Iron.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

SPECIFICATION of No. 22

Self-Acting, Sliding, Surfacing, and Screw-Cutting Lathe.



Weight, 5 Tons.

FITTED with double-geared headstock, steel spindle, conical necks, gunmetal bearings, reversing motion for cutting right and left-hand screws; the loose headstock is fitted with cylinder mandrel, and left-hand square thread traverse screw, bright turned hand wheel, and can be made to set over by transverse slide motion for taper turning, if desired. The saddle has a flush top and T grooves for bolting work for boring purposes, compound slide rest, made to swivel to any angle for surfacing, and graduated for turning conical. The bed is accurately planed and surfaced, and provided with movable bridge-piece for gap, box end at left hand, and firmly bolted to strong standards with planed faces at right-hand end. The metal is carefully distributed, so that the Lathe is quite rigid under the heaviest cutting strain; the leading screw is of steel, accurately cut, and extends full length of bed. It has a double clam gunmetal nut, actuated by eccentric movement to engage and release the saddle, the latter having also a quick hand traverse by rack, pinion, and double-purchase gearing. The self-acting, sliding, and surfacing motions are arranged with back shaft and worm gearing.

The Lathe is fitted with back traversing stay, 22 change wheels, index plate, 24in. face-plate, catchplate, and top driving apparatus, screw keys, &c.

Above Lathes are made with 10*in.*, 12*in.*, 14*in.*, 16*in.*, *and* 18*in.* *Centres, and with Beds of any length.*

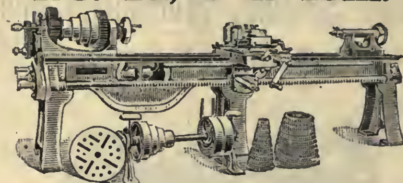
	£	s.	d.
Price, Sliding and Screw-Cutting			
„ Sliding, Surfacing, and Screw-Cutting ..			
Poppet to Set over for Taper Turning, extra ..			
Extra Length of Bed, per foot			

These Lathes are fitted for hard and accurate work; and are similar to those supplied to the British Government, to Davey Paxman & Co., and other eminent firms.

For larger sizes, see Special Circular. Lathes up to 30*ft. with two or more heads.*

Self-Acting, Sliding, Surfacing & Screw-Cutting Lathe,

No. 24, 9 & 10in.



THIS Lathe is a stiff-bnilt tool for heavy work, np to its capacity of size, and is strong enough to raise to 10in. for lighter work. It is well proportioned in all parts and is constrncted with gap bed, accurately planed and surfaced, and bridge piece fitted to gap; donble-geared headstock, steel spindle, conical neck, gun-metal bearings, reversing motion for cutting either right or left hand screws, loose head with cylinder barrel and left hand square thread traverse screw, and made to set over for taper turning if required; steel leading screw accnrately cut, and extending full length of bed, with double clam gun-metal nnt, clipping screw at top and bottom, saddle with long wings, flush top, and grooved for bolting work to for boring, and with qnick hand traverse by rack and pinion, compound slide rest to swivel to any angle, graduated for turning conical, &c., and steel draw screws; back surfacing shaft and worm gearing for sliding withont the leading screw (saving wear of same) and for snrfacing. The price includes back following stay, catch and face plates, 22 change wheels, index plate, overhead motion, screw keys, &c., complete. All materials and workmanship gnaranteed.

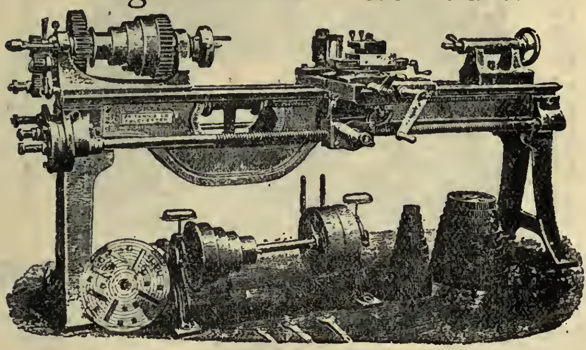
DIMENSIONS, PRICES, &c.

Height of Centres	9in.
Length, breadth, and depth of Bed	12ft. by $14\frac{1}{2}$in. by 10in.
Length and diameter will swing in Gap ...	15in. by 38in.
Diameter and pitch of Steel Leading Screw	2in. by $\frac{1}{2}$in.
Diameter of Back Snrfacing Shaft	$1\frac{1}{4}$in.
Number and width of Speeds ou Cone Pnlley	4—3in.
Diameters of largest and smallest Speed	12in. and $4\frac{1}{2}$in.
Width on face and pitch of Gearing	$2\frac{1}{2}$in. by $\frac{7}{8}$in.
Diameters of large and small Gear ...	13in. and $4\frac{1}{4}$in.
Diameters of body and nose of Steel Spindle	2in. and $2\frac{1}{2}$in.
Pitch of the 22 Change Wheels	$\frac{7}{16}$in.
Extreme length between Centres	7ft. 6in.
Approximate Weight	35cwt.

	9in. Centre. £	s.	d.	10in. Centre. £	s.	d.
Price with Leading Screw and Back Shaft						
Price with Leading Screw only..						
Poppet to Set over, extra						
Extra length of Bed per foot						

The Britannia Company designed these Lathes for the British Government. The wearing parts are steel.

Self-Acting, Sliding, Surfacing, & Screw-Cutting Lathe Nos. 25 and 20.



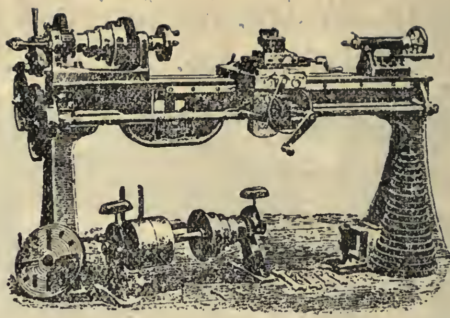
WITH gap bed, accurately planed and surfaced, and bridge piece fitted to gap; double-geared headstock, steel spindle, conical neck, gun-metal bearings, reversing motion for cutting either right or left hand screws, loose head with cylinder barrel and left hand square thread traverse screw, and made to set over for taper turning if required; steel leading screw, accurately cut, and extending full length of bed, with double clam gun-metal nut, clipping screw at top and bottom, saddle with long wings, flush top and grooved for bolting work to, for boring, and with quick hand traverse by rack and pinion, compound slide rest to swivel to any angle, graduated for turning conical, &c., and steel draw screws, back following stay, catch and face plates, 22 change wheels, index plate, overhead motion, screw keys. &c., complete. All materials and workmanship guaranteed. These Lathes up to 10ft. have 2 standards, above 10ft. 3 standards.

DIMENSIONS.	No. 25 LATHE.	No. 20 LATHE.
Height of Centres..	$7\frac{1}{2}$in.	9in.
Length, breadth, and depth of Bed	8ft. by $10\frac{3}{4}$in. by 8in.	10ft. by 13in. by $8\frac{1}{2}$in
Length and diameter will swing in Gap ..	11in. by 31in.	12in. by 36in.
Diameter and pitch of Steel Leading Screw	$1\frac{1}{2}$in. by $\frac{1}{2}$in.	$1\frac{7}{8}$in. by $\frac{1}{3}$in.
Diameter of Back Surfacing Shaft	$1\frac{1}{8}$in.	$1\frac{1}{8}$in.
Number and width of Speeds on Cone Pulley	4 by $2\frac{1}{4}$in.	4 by $2\frac{1}{2}$in.
Diameters of largest and smallest Speed ..	$8\frac{1}{2}$in. and $3\frac{3}{4}$in.	10in. and $4\frac{1}{2}$in.
Width on face and pitch of Gearing	$2\frac{1}{4}$in. by $\frac{5}{8}$in.	$2\frac{1}{4}$in. by $\frac{3}{4}$in.
Diameters of large and small Gear	10in. and $3\frac{1}{4}$in.	11in. and $3\frac{1}{2}$in.
Diameters of body and nose of Steel Spindle	$1\frac{1}{2}$in. and 2in.	$1\frac{3}{4}$in. and $2\frac{1}{4}$in.
Pitch of the 22 Change Wheels	$\frac{3}{8}$in.	$\frac{3}{8}$in.
Extreme length between Centres	4ft. 6in.	6ft. 6in.
Approximate Weight	16 cwt.	26 cwt.
Price with both Leading Screw & Back Shaft		
Price with Leading Screw only		
Poppet to set over, extra		
Extra length of Bed per foot		
Beds to any length.		

These Lathes are as made for the British Government.
THE WEARING PARTS ARE STEEL.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

Any Lathe can be made with Cut Gear Wheels at an Extra Charge.



Chucks of Every Description to Order.

No. 17.—6in., 7in., and 8in. Centre LIGHT SELF-ACTING SLIDING and SCREW-CUTTING LATHE.

6in. CENTRE.

With gap bed accurately planed and surfaced, and bridge-piece fitted to gap; double-geared headstock; steel spindle with conical neck; gun-metal bearings; reversing motion for cutting right and left-hand screws; The loose head has cylinder barrel and left-hand traverse screw, and made to set over for taper turning if required; steel leading screw accurately cut, and extending full length of bed, with double clam gunmetal nut, gripping screw at top and bottom; saddle with long wings, flush top, and grooved for bolting work to, when boring; quick hand traverse by rack and pinion; compound slide-rest to swivel to any angle, graduated for turning conical; steel draw screws; back following stay; catch and face plates; twenty-two change wheels; index plate; overhead motion; screw keys, &c., &c. All materials and workmanship guaranteed.

SPECIFICATION:—

Height of Centre, 6in.; Breadth of Bed, 8$\frac{3}{4}$in.; Depth of Bed, 6in.; Width of Gap, 7$\frac{1}{4}$in.; Depth of Gap, 6in.; Diameter of Leading Screw, 1$\frac{1}{2}$in.; Pitch of Leading Screw, $\frac{1}{4}$in.; Diameter of Back Shaft, 1in.; Change Wheels (22), $\frac{5}{16}$in. Pitch; Cone Pulley, 4 speeds, 2in. Broad; Large Cone, 7$\frac{3}{4}$in. Diameter; Large Gear, 8$\frac{1}{2}$in. Diameter; 1$\frac{1}{2}$in. Broad, $\frac{9}{16}$in. Pitch; Body of Spindle, 1$\frac{3}{8}$in. Diameter. Approximate Weight with 6ft. Bed, 13$\frac{1}{2}$cwt. Swing in Gap, 12in. Admits between centres of 6ft. Lathe, 3ft. 6in.

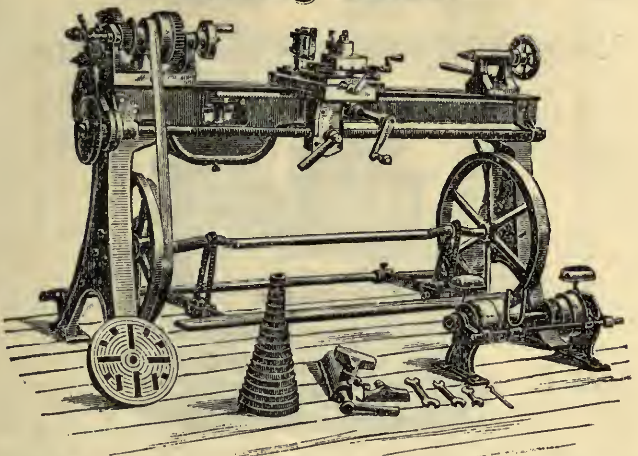
	6in.		7in.		8in.	
	£	s.	£	s.	£	s.
Price, Sliding and Screw-Cutting	**37**	**16**	**40**	**16**	**42**	**16**
Price for Self-acting Sliding, Surfacing, and Screw-Cutting (by Back Shaft)	**44**	**2**	**47**	**2**	**49**	**2**
Poppet to set over, extra	**1**	**0**	**1**	**0**	**1**	**0**
Extra Length of Bed, per foot	**2**	**0**	**2**	**0**	**2**	**0**
If fitted with Crank Shaft and Treadle Motion instead of Overhead Motion, extra	**6**	**0**	**6**	**0**	**6**	**0**

When Beds are longer than 6ft., an Extra Standard is added.

Many of the above Lathes have been made for the British Government.

No. 16.

Self-Acting, Sliding, and Screw-Cutting Lathe.



With gap bed accurately planed and surfaced, and bridge piece fitted to gap; double-geared headstock; steel spindle with conical neck; hard steel or gunmetal collars; reversing motion for cutting right and left-hand screws; the loose head has cylinder barrel and left-hand traverse screw, and made to set over for taper turning if required; steel leading screw accurately cut, and extending full length of bed, with double clam gunmetal nut, gripping screw at top and bottom; saddle with long wings, flush top, and grooved for bolting work to when boring; quick hand traverse by rack and pinion; compound slide rest to swivel to any angle, graduated for turning conical, and steel draw screws; back following stay; catch and face plates; twenty-two change wheels; index plate; treadle motion; screw keys, &c., &c. All materials and workmanship guaranteed. The 5ft. Lathe measures 3ft. 2in. between centres; 6ft. measures 3ft. 10in. between centres.

SPECIFICATION.

Breadth of Bed	7 inches.	6in. Cone Pulley, 3 speeds	$1\frac{1}{2}$in. broad.
Depth of Bed	$5\frac{1}{2}$,,	5in. Cone Pulley, 3 speeds	$1\frac{1}{4}$in. broad.
Width of Gap	$6\frac{1}{2}$,,	Large Cone	$6\frac{1}{2}$in. diameter.
Depth of Gap	$5\frac{1}{2}$,,	Large Gear of 5in., $6\frac{3}{4}$ diameter; 6in. centre, $7\frac{3}{4}$ diameter; $1\frac{1}{4}$in. broad.	
Diameter of Leading Screw .	$1\frac{1}{4}$,,	Nose of Mandrel . .	$1\frac{1}{2}$in. diameter.
Pitch of ,, ,, .	$\frac{1}{4}$,,		
Diameter of Back Shaft .	1 ,,		
Change Wheels, 22 .	$\frac{1}{4}$in Pitch.		

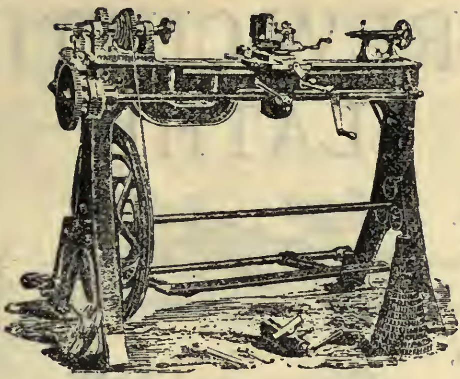
Approximate Weight: 6in., with 6in. Bed, $10\frac{1}{2}$cwt.; 5in. centre, 5ft. Bed, 9cwt.

Price, Sliding and Screw Cutting, 5in. Centre, 5ft. Bed - -	*£31 10 0*
Do. do. 6in. Centre, 6ft. Bed - -	*35 14 0*
Extra Length of Bed, per foot - - - - - - -	*2 0 0*
If made without Treadle, but with Overhead for Steam Power, 5in. Centre, 5ft. Bed -	*30 0 0*
Do. do. 6in. Centre, 6ft. Bed -	*34 0 0*
If Self-acting, Sliding, Surfacing, and Screw Cutting (by Back Shaft and Leading Screw), extra - - - - -	*4 4 0*
Poppet to set over, extra - - - - - - - -	*1 0 0*
If with Cone Speed for Gut Band instead of Flat Belt, deduct -	*1 1 0*

The above is as supplied to the British Government

No. 15 LATHE.

Overhead Motions similar to that shown on the Lukin Lathe, extra.



Ornamental Drill Spindle, 42/-

Self-acting Sliding and Screw-cutting, with 4ft. gap bed, back-geared headstock, cast steel mandrel, conical necks running in hardened collars, steel lock nuts and back centre, cone pulley, turned 3 speeds for gut band, fitted with reversing motion for cutting right or left-hand screws. Compound slide rest, with long bearings, accurately fitted to bed. The top slide is made to swivel, and is graduated to 50° each side of centre, to turn cones to any angle. The tail-stock has cylinder mandrel, square thread traverse screw, bright turned hand wheel.

The bed is accurately planed, and is 6⅛in. wide and 4¼in. deep. The gap is 4¼in. deep and 6in. wide. Steel leading screw, 1⅛in. diameter and ¼in. pitch; the gunmetal nut for ditto is in halves to detach. The Lathe is fitted with rack and pinion for quick return. It has a full set of 22 change wheels, to cut from 1 to 60 threads per inch, is fitted with steel centres, faceplate, catchplate, double spanner. Strong iron stand, with improved treadle motion, with adjustable outside crank and friction rollers, or with ordinary crank and pitman. The 4ft. Lathe measures between centres 2ft. 6in., swings 1ft. 4in. in gap. The flywheel is counterbalanced, and has 5 speeds. Weight of 4in. Lathe, about 5cwt.

These Lathes can be fitted with Overheads for Steam Power at 30/- less than for Foot Power.

Price, with 4in. centre, £25 4s.; 4½in., £26 15s. 6d.; 5in., £28 7s.

Cut Gear Wheels at an Extra Charge.

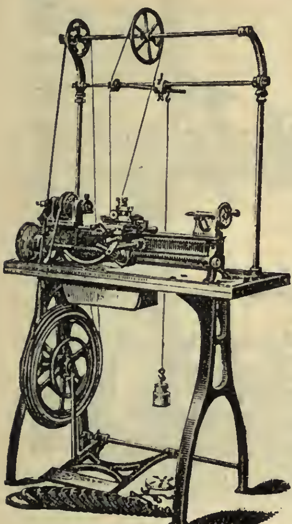
If Self-acting and Surfacing by back shaft, extra, **£4**. *If with Flat Speed Pulleys,* **21s.** *extra. Set over Poppet,* **30s.** *extra. If with 5ft. Bed,* **£2** *extra.*

The 5in. Flat Speed Belt Pulleys have 3 speeds—3¼in., 4⅜in., and 6¼in.—1in. gearing, ¾in. face, by 6⅝in. diameter, 10in. pitch. The 4in. Flat Speed Belt Pulleys have 3 speeds—2½in., 3⅞in., and 5⅞in.—1in. gearing, ¾in. face, by 5⅝in. diameter, 12in. pitch.

The Leading Screws and Wearing Parts are Steel.

LATHE No. 13.

Improved Self-acting, Sliding, and Screw-cutting Gap Bed Lathe, of superior finish, best material and workmanship.



SPECIFICATION.—3in. centre, 30in. gap bed; the headstock is back-geared with cast steel spindle, conical necks, steel lock nuts and back centre, coned pulley, turned three speeds for gut band, fitted with reversing motion for cutting right and left hand screws; compound slide-rest on carriage, with long bearings accurately fitted and scraped to bed, and well gibbed. The top slide is made to swivel, and is graduated to 50° each side of centre to turn cones to any desired angle; strong tool holder with steel screws; tail stock of good design, cylinder mandrel, square thread traverse screw, bright turned hand wheel. The bed (machine planed) is $3\frac{1}{2}$in. on face, $2\frac{3}{8}$in. deep, with gap $2\frac{1}{4}$in. deep and $2\frac{7}{8}$in. wide. The leading screw is $\frac{7}{8}$in. diameter $\frac{1}{4}$in. pitch, accurately cut; the gun-metal nut is in halves to detach, and lathe is fitted with rack and pinion for quick return motion. It has a full set of 22 change wheels to cut screws from 1 to 60 threads per inch; it is fitted with face plate, catch plate, steel centres, double spanner, and mounted on an iron stand, with polished wood top, and drawer; fly-wheel 20in. diameter, with four turned speeds, treadle motion, &c., complete. Measures between centres, 19in.; swings, $10\frac{1}{2}$in. by $2\frac{7}{8}$in. in gap, 6in. over the bed, and $4\frac{1}{2}$in. over the carriage. Total weight, about $2\frac{1}{4}$cwt.

Price 15 Guineas.

Ditto, with 3ft. Gap Bed..	..	16 Guineas.
„ 3ft. 6in.	„	17 „

Overhead Motion for Ornamental Turning, as illustration, £3 15s.

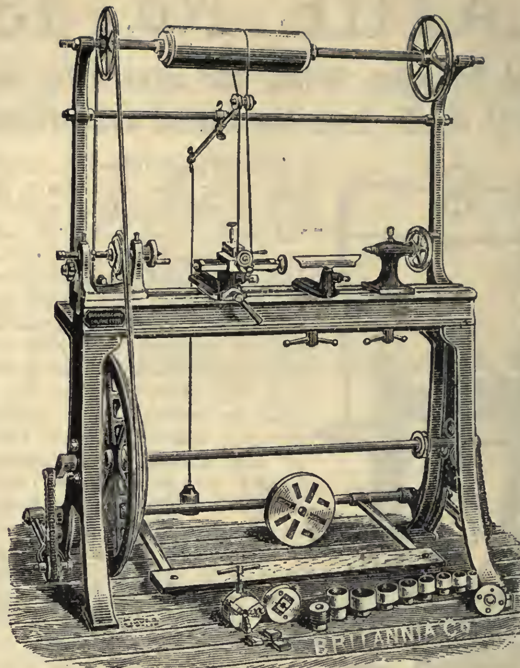
Drill Spindle, 30s.

Extra Hard Mandrel and Collars, 30s. extra.

Self-surfacing off Leading Screw. £2 10s. 0d. extra.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

Lathes made to any Design.



CONSTRUCTED TO THE DESIGN OF J. LUKIN, B.A.

THE LUKIN LATHE.

FOR ORNAMENTAL TURNING.

IT is fitted with Traversing Mandrel and Six Guides for Chasing Screws on Microscopes, Telescopes, and similar metal work, or on Box-lids and similar work in wood. A great variety of beautiful ornamental work may be done by suitable appliances.

Price of Lathe, 5in. centre, 4ft. 6in. bed, with Traversing Mandrel and Six formers	£22	10	0
Ornamental Overhead	7	10	0
Ornamental Slide Rest	10	10	0
Division Plate	2	10	0
Plain Slide Rest	5	0	0
Ornamental Drill Spindle	1	10	0

Price extra if bed be 4ft. 6in., 12/6; or 5ft. long, 25/-. Price extra of bed with gap, 20/-

Oval, Eccentric, Geometric, or any of the Chucks or Appliances in our list can be fitted at list price.

Above Lathe cuts Screws of any pitch by means of a "Firmer" or Dummy Screw on end of Mandrel.

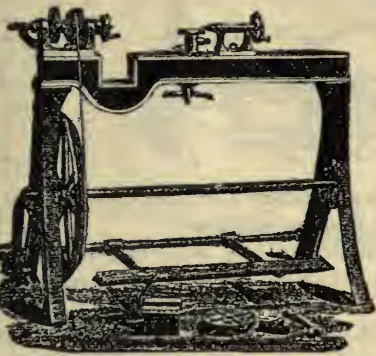
BRITANNIA WORKS, COLCHESTER, ENGLAND.

IMPROVED FOOT LATHE.

No. 5.

4in. to 6in. Centres.

THIS is a similar Lathe to the No. 4, but with heavier Bed, Standards, and Fly Wheel—altogether of a stronger and more substantial description. Bed is 4ft. long and 4½in. on face; total weight of Lathe, about 4½ cwt. It has an Improved Treadle Motion, combining great power with ease of motion; the bright turned shaft on which wheel is keyed runs in Friction Rollers at each end. The Head is fitted with steel mandrel and collars. The Crank (as illustration shows) is *outside* the left-hand standard, and is slotted in order that the driving stud may be adjusted to give more or less leverage, to increase or decrease power at will of the operator. The Fly Wheel is counterbalanced to avoid dead centre.



Each Lathe is accompanied by Hand Rest with Two Tees, two Face-plates (large and small), two Plain Centres, and Spanners.

		£	s.			£	s.
4in. Centre	...	**11**	**0**	**Back Geared**	...	**13**	**0**
4½ „	...	**11**	**10**	„	...	**13**	**15**
5 „	...	**12**	**0**	„	...	**14**	**10**

If with 5ft. Bed, 20s. extra. Extra Large Face-plate to suit, £1 extra. Gap Bed, 20s. extra.

A similar Lathe, with 5in. and 6in. centre, heavier bed, 5½in. on face, 5ft. long, weight about 5½ cwt.—

5in. Centre, Single Geared, £14; Back Geared, £16; or with 6ft. Bed, 20s. extra. If with 6in. Centre, 20s. extra.

☞ *Headstocks fitted with extra hard Mandrel and Collars*, 30s. extra. *Overhead similar to the Lukin*, £5 5s. *Ornamental Drill Spindle*, 42s.

THE ABOVE LATHES CAN BE FITTED WITH HOOKS AND CRANKS INSTEAD OF CHAINS.

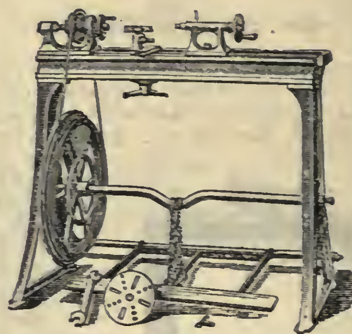
The Lathes with 4ft. Bed will measure 2ft. 4in. between Centres.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

IMPROVED FOOT LATHE.

No. 4.

This Lathe can be fitted with Overhead similar to the Lukin, £5 5s. extra.



Ornamental Drill Spindle, 30s.

Division Plates to order.

THIS illustration represents an excellent Foot Lathe especially suited for Gasfitters, Jewellers, Dentists, or Amateurs.

It has a machine-planed iron Bed, 3ft. long, on strong iron standards, with 4-speed turned fly-wheel, and an easy, light-running treadle movement.

The single-geared headstock has a steel mandrel, with hard-coned neck running in hard collar.

The back-geared headstock has a steel mandrel, with reverse cones (adjustable to take up wear), and running in steel collars, steel-coned centre, 3-speed turned coned pulley.

The tailstock has cylinder mandrel, with square thread steel traversing screw and steel-coned centre. Each Lathe is accompanied by hand rest, with two tees, two face-plates (large and small), two plain centres, spanner, and tool-table. The 3ft. Lathe takes 1ft. 6in. between centres.

Slide-rests and various chucks, &c., as per List.

Strength and durability are obtained, in a high degree, without clumsiness.

		£	S.	D.			£	S.	D.
3½in. Centre	..	8	0	0	**Back Geared**	..	10	0	0
4 " "	..	8	10	0	"	..	10	15	0
4½ " "	..	9	0	0	"	..	11	10	0
5 " "	..	9	10	0	"	..	12	0	0

3ft. 6in. Bed, 10s. extra; 4ft. Bed, 20s. extra.

If with Gap Bed and Bridge, £1 extra.

Extra Large Face-plate, to use with Gap Bed, £1.

Extra-hardened Mandrel and Collars, 30s. extra.

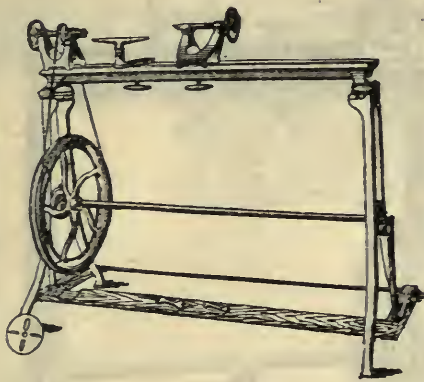
Approximate Weight, 2cwt. 3qr. 0lb.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

No. 10.

CHEAP WOOD TURNING LATHE.

A MULTUM IN PARVO LATHE.



THE BEST THAT CAN BE MADE AT THE PRICE.

THE very great demand for a cheap but efficient Lathe for wood turning, with long bed and high centres, suitable for pattern-makers, joiners, and amateurs, has led us to introduce the above, and we fix the price so low as to bring it within the reach of the million.

It is entirely constructed of iron and steel, except the treadle, which is of hard wood for quietness and lightness.

The planed cast-iron bed is 4ft. long, 4in. wide, and 4in. deep; iron standards, arranged with adjusting swivelling bearings for the steel wheel-shaft. The driving-wheel has two speeds, and is about 21in. diameter. The parallel bearings of the fast head are split, and fitted with screws to take up wear.

The steel mandrel is made with a collar forged on, with a ⅝in. nose screwed Whitworth standard, to which most of our ordinary chucks may be at any time fitted; the tail end of this mandrel carries a balance wheel. The cone pulley has two speeds, corresponding with driving-wheel.

Turned steel centres, with taper shanks, to fit into spindles. Face-plate 5in. diameter, fork driver-chuck, hand rest and 9in. tee, spanner, and belt, are sent with each Lathe.

Height from floor to top of bed, 36in.; height of centres from bed, 5in.; extreme distance between centres, 36in.; total weight, 144lb.

Price, complete, £4 10s.; as Bench Lathe only, £3 10s.

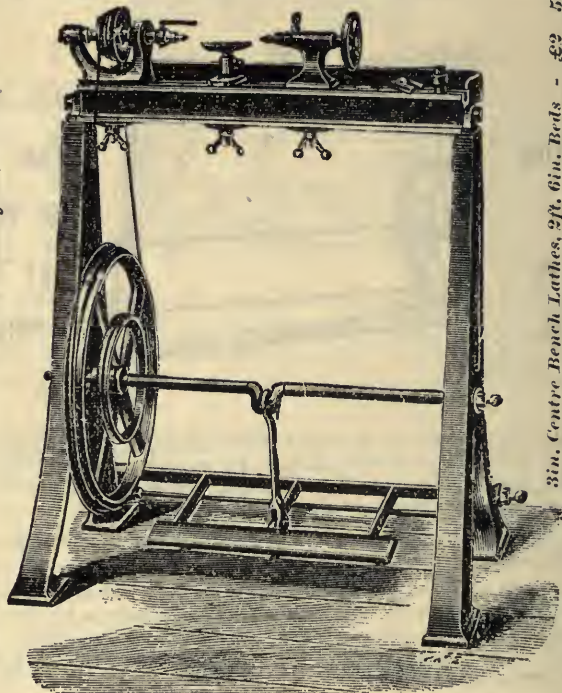
BRITANNIA WORKS, COLCHESTER, ENGLAND.

NEW

SINGLE-GEARED LATHE.

No. 8.

For Bench Lathes and numerous Appliances, see our Catalogues.



3in. Centre Bench Lathes, 2ft. 6in. Beds	*£2 5s.*
Back-Geared do.	*£4 10s.*
Tripod and Fly Wheel	*£1 10s.*
Standards and Fly Wheel	*£2 0s.*

3½in. Centres. 2ft. 6in. Bed.

WILL TAKE 16½ INCHES BY 7 INCHES BETWEEN CENTRES.

THE above is introduced to supply a demand for a Lathe coming between our No. 3 and No. 4 patterns. It is fitted with gunmetal mountings, and it can be recommended with confidence for general light turning, and for amateurs, clockmakers, &c.

It is thoroughly well made, and very light running. The fast head is fitted with best steel mandrel and best steel collar, both hardened, 4-speed turned cone pulley, nose ⅝in. Whitworth; the loose head has steel cylindrical spindle, square thread traverse screw, best steel centres, hand rest and 2 tees, machine-planed cast-iron bed, 3¼in. face, 3in. deep, securely bolted to cast-iron standards; wrought-iron crank shaft and treadle, working on steel centres, turned speed fly-wheel, tool board, leather driving cord, driver chuck, drill chuck, &c., complete.

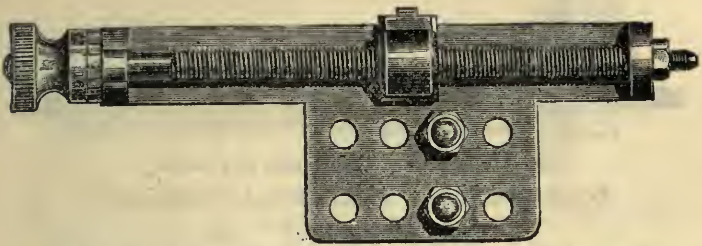
Weight, 180lb.

Price £6 10s., or with 3ft. Bed, £7.

Slide-rest, Chucks, Tools, &c., see List.

BRITANNIA COMPANY'S

Registered Screw-Cutting Guide.



THE above appliance can be used on any Lathe. By its use the workman can regulate the depth of cut to the greatest nicety, and the use of the chalk mark, or any such expedient, is unnecessary.

It can be used for inside or outside screw-cutting, or other work requiring uniformity. It saves time from insufficiency of cut. It prevents the breaking of tools, or the work being torn out from the centres. It is a reliable stop for ornamental drilling and fluting.

While the Lathe is cutting this can be adjusted for the following cut. It only requires to be bolted upon the saddle of a Screw-cutting Lathe, and a projecting stud or screw fixed in the middle slide engages the stop.

It can also be used on ordinary Lathes with slide rest; in this case it must be fixed to the bed.

This is a tool which has long been wanted by engineers, and will also be appreciated by amateurs.

PRICES.

For 3in. to 4in. Centre Lathes		... ...	*18s.*
5in. and 6in.	,,	... ...	*20s.*
8in. to 10in.	,,	... ...	*22s. 6d.*

Sole Makers:—BRITANNIA COMPANY,

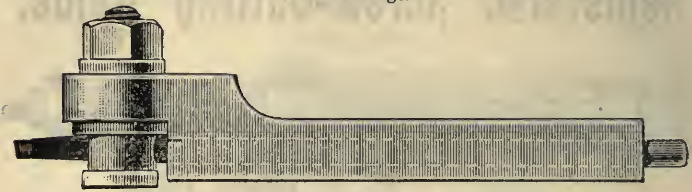
100, HOUNDSDITCH, LONDON.

All Letters to Britannia Works, Colchester.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

Bent's Patent Boring Tool.

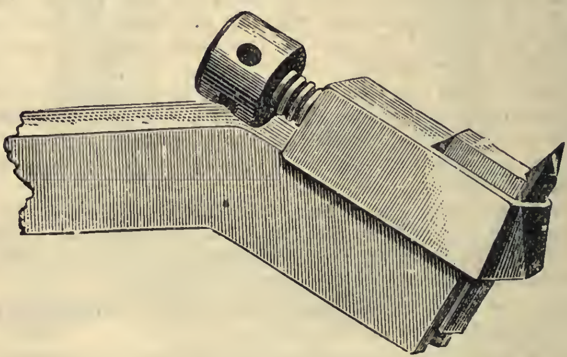
Invented by B. H. BENT, B.A., Demonstrator of Applied Mechanics, University of Cambridge.



Same Prices as the HAYDON (see below).

SOLE MAKERS: BRITANNIA COMPANY.

HAYDON TOOL-HOLDER.



ADVANTAGES.

Users of these Holders save the cost and inconvenience of forging their tools.

The Cutters are easily sharpened to the correct angle.

By due attention to the instructions superior finish can be given to the work.

A stock of the small Cutters can be always kept sharpened, as they cost but little, and occupy a small space.

The steel of which the Cutters are made can be bought in 12in. or 14in. lengths, and cut off as required, or Cutters can be purchased at 6d. each.

Plain directions for sharpening Cutters to the **exact angle** required for various metals, and how to use the tools to best advantage, will be sent with each Bar. A diagram showing the various angles will prevent the possibility of errors in judgment.

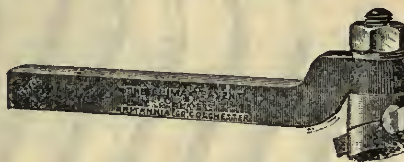
				s.	d.
$\frac{3}{8}$in. Bars, will suit Lathes	3in. and $3\frac{1}{2}$in. centre ...	Price		9	6
$\frac{1}{2}$in. ,, ,,	4in., $4\frac{1}{2}$in., and 5in. ...	,,		10	0
$\frac{9}{16}$in. ,, ,,	5in. or 6in.	,,		10	0
$\frac{3}{4}$in. ,, ,,	6in. and 7in.	,,		12	6
$\frac{7}{8}$in. ,, ,,	7in. to 9in.	,,		15	0
1in., for larger sizes	... ...	,,		17	6

BRITANNIA WORKS, COLCHESTER, ENGLAND.

The "Climax" Tool-holder

(PATENT).

For Lathes, Shaping and Planing Machines, &c.



THE advantages and great saving the Tool-holder possesses over the forged tool are proved by its adoption by the leading firms of engineers both in this country and in America.

The "Climax" Tool-holder is designed to meet the demand for a useful all-round cutting-tool, which will cut straight or irregular work, and into corners, and face either right or left, without altering its position in the slide rest.

The important improvement in this Tool-holder over those already in use lies in the fact that side rake as well as top rake can be given to the cutter, which thus always presents the correct cutting angle to the work. The object of this side rake is not only to make the tool more keen without sacrificing its strength, but to relieve the feed screw or gearing of strain by giving the tool a tendency to feed along and into its cut.

The cutter is held perfectly rigid in any position by tightening a single nut.

This Holder is invaluable for screw-cutting, as the cutter can be canted to suit the angle of any thread, either V or square.

The "Climax" Tool-holder is made entirely of steel, the bolt, &c., being case hardened, and is of the best workmanship and finish.

The cutting tools are of uniform section, made from the finest cast steel obtainable.

Cutters of Mushet's special self-hardening steel can be supplied for the two larger sizes. This steel is strongly recommended, and machine tools should be worked at faster speeds and with deeper cuts when using it.

Section of Cutter.	Size of Shank.	Suitable for use in Lathes to	Price of Tool-holder.	Price of best Cast Steel Cutters Per dozen.	Price of Mushet's Steel Cutters Per dozen.
			£ s. d.	£ s. d.	£ s. d.
$\frac{5}{16}$in. × $\frac{1}{8}$in.	$\frac{9}{16}$in. sq.	4in. centres	0 13 6	0 4 6	——
$\frac{3}{8}$in. × $\frac{5}{32}$in.	$\frac{5}{8}$in. ,,	4½in. ,,	0 14 0	0 5 0	——
$\frac{1}{2}$in. × $\frac{3}{16}$in.	$\frac{11}{16}$in. ,,	5in. ,,	0 14 6	0 5 6	——
$\frac{3}{8}$in. × $\frac{1}{4}$in.	$\frac{3}{4}$in. ,,	6in. ,,	0 15 0	0 6 0	0 8 0
$\frac{7}{8}$in. × $\frac{3}{8}$in.	$\frac{7}{8}$in. ..	10in. ..	1 0 0	0 8 6	0 11 0

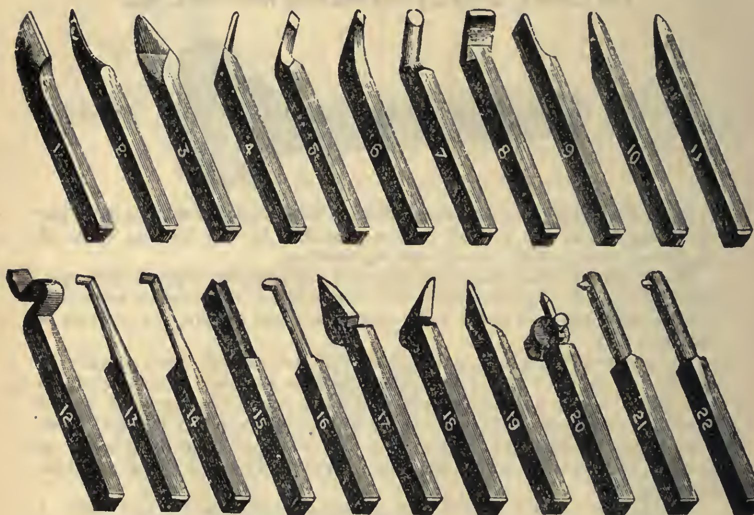
Angle Gauges, 4/6 each.

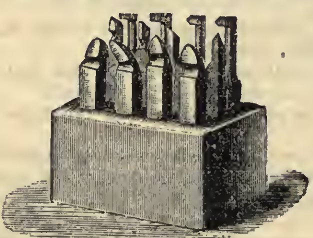
Special Quotations for Larger Sizes.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

SLIDE REST TOOLS

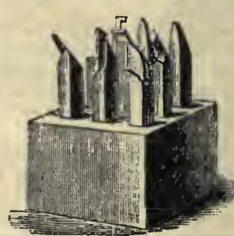
In great variety, made of the very best Steel.





Sets of Tools—12, with Block.

$\frac{3}{8}$in., 12/- $\frac{5}{8}$in., 19/6
$\frac{1}{2}$in., 16/- $\frac{3}{4}$in., 22/9



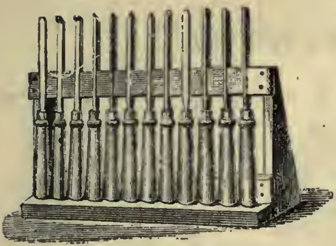
In Sets of 9, with Block.

$\frac{3}{8}$in., 10/- $\frac{5}{8}$in., 15/-
$\frac{1}{2}$in., 12/6 $\frac{3}{4}$in., 17/6

The Patterns most generally used are: No. 1 to No. 19.
Sold Singly or in Sets.

	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	inch.	
	1/-	1/3	1/6	1/9	each.	
No. 20.	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	inch.	
	4/6	5/-	6/-	7/-	each.	
No, 21 / No. 22	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	inch.
	2/6	3/-	3/-	4/-	5/-	each.

LATHE TOOLS.

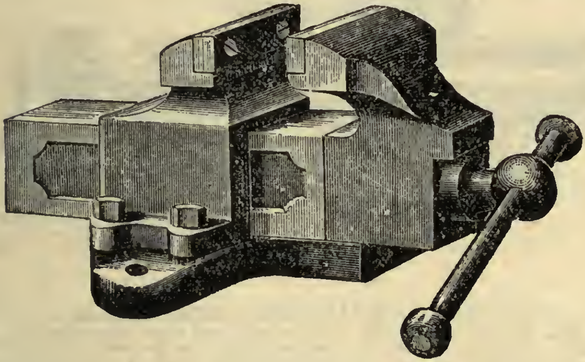


Hand Turning Tools in great variety, 1s. each, 10s. per doz.

Larger sizes, 1s. 3d., 1s. 6d., and 2s. each.

Long Handles if specially ordered.

STANDS TO HOLD TOOLS from 2/6.



PARALLEL BENCH VICES,

WITH STEEL JAWS.

MADE IN THREE SIZES.

	No. 1.		No. 2.		No. 3.
Measure across jaw ...	$2\frac{3}{4}$in.	...	$3\frac{1}{4}$in.	...	$3\frac{3}{4}$in.
Will open	$3\frac{1}{2}$in.	...	4in.	...	5in.
Weight	11lb.	...	18lb.	...	29lb
Price	**10/6**	...	**17/6**	...	**25/-**

CASTINGS AND FORGINGS FOR ABOVE VICES.

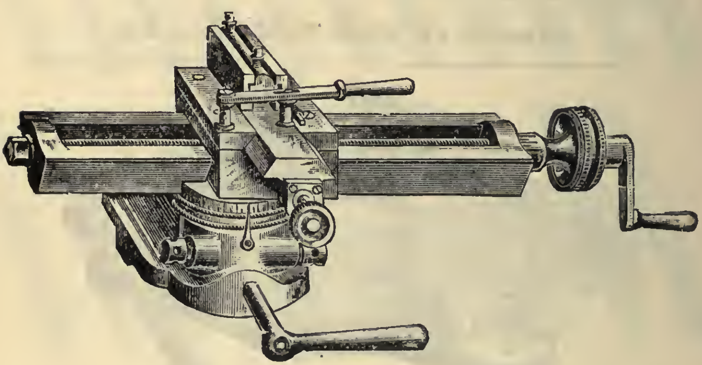
	No. 1.		No. 2.		No. 3.
In rough	4/-	...	6/9	...	10/-
If planed, screw-turned, and cut ...	7/6	...	12/-	...	18/-

The Britannia Company's

ORNAMENTAL

SLIDE-REST

AS SUPPLIED WITH LUKIN LATHE.

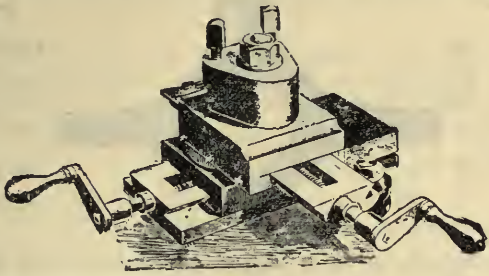


The above Illustration represents our Ornamental Slide-rest constructed to suit a 5in. Lathe, and embodying all the most material and useful improvements. It is arranged with a gunmetal cradle planed to fit the lathe bed, and slide along it to any part, and planed at top to receive an eccentric socket at right angles to the bed. The socket is 12in. long, planed parallel at sides to slide along the gunmetal cradle, and adjust to any distance from axial line of centres. Within it is an eccentric shaft with eye and nut, a half-turn of which rigidly secures it to the lathe bed. At its top rim it is turned and screwed, and fitted with a gunmetal ring with milled edge to turn by thumb and finger, to adjust the height of the cutter. The longitudinal slide is 12in. long, made with a turned shank to fit into the socket of eccentric slide, and swivel to any angle, its circular bottom being graduated to 50 deg. each side of centre. Along its upper face are graduations in 10ths of an inch, and it is fitted with a steel draw-screw having 10 threads per inch, with cones at each end to take up wear, and with a split gunmetal nut to adjust to take up back-lash. On the collar of the screw are 20 divisions, to give an adjustment to 200ths of an inch, and it has a long milled-edged knob for thumb and finger adjustment, and grooved for gut to enable it to be driven from overhead gear; it also has a square at its end fitted with crank and handle. The top slide is made of gunmetal, fitted to longitudinal slide by loose adjusting strips, with a transverse slide carrying tool-holder to suit $\frac{3}{8}$in. tools, and actuated by a milled head thumbscrew and garter slide, screwed to 20 per inch, graduated by an ingenious contrivauce to 25 divisions, giving an adjustment of the tool to the 500th part of an inch. The garter slide is instantly detachable, enabling the slide and tool-holder to be operated freely by lever. A stop screw is fitted to the tool-holder, and the face of the slide is graduated in 20ths of an inch. The whole instrument is well devised, very complete, and accurately and carefully made.

PRICE 15 GUINEAS.

BRITANNIA CO.'S

Improved Compound Slide Rest.



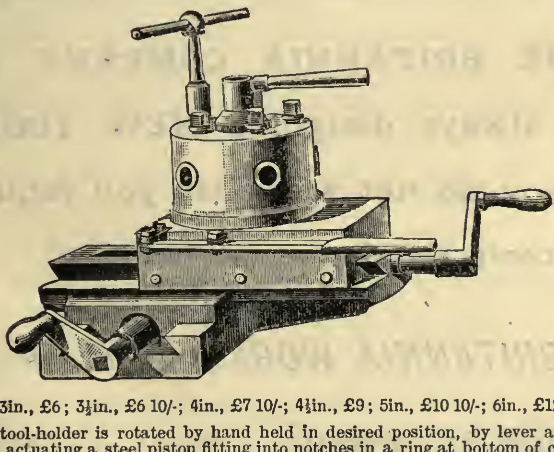
To suit 2¼in. centre Lathe ..	£2 0 0	To suit 5in. centre Lathe ..	£5 0 0
" 3in. " ..	2 10 0	" 6in. " ..	6 0 0
" 3½in. " ..	3 0 0	" 7in. " ..	7 0 0
" 4in. " ..	3 10 0	" 8in. " ..	8 0 0
" 4½in. " ..	4 0 0	Larger sizes, £1 per inch.	

These are made so that the bottom slide always remains at a right angle with the lathe bed, the rest having a swivel arrangement, accurately graduated, for turning taper or conical work to any desired angle. The bottom cover, extending full length, excludes turnings and dirt from the screw and slide. The materials are of the best: Screws are cast steel, gunmetal nuts, horn handles, improved tool-box, with hardened steel screws. The workmanship is excellent. The slides, &c., are surfaced up, and the parts, being machine-made and uniform, are interchangeable.

We also make two other patterns, with long slide. Tool holders, with plates, or other patterns to order.

CAPSTAN OR TURRET RESTS.

To hold five tools of any desired form, for doing various work at one setting.



For 3in., £6; 3½in., £6 10/-; 4in., £7 10/-; 4½in., £9; 5in., £10 10/-; 6in., £12 15/-.

The tool-holder is rotated by hand held in desired position, by lever and link motion actuating a steel piston fitting into notches in a ring at bottom of capstan. When used with hollow mandrel, lathe-work is expeditiously finished from the rod.

PATENT DOUBLE-DRIVING CARRIERS.

Prices:		**Prices:**
$\frac{3}{8}$in. to $\frac{3}{4}$in. 2/6		$2\frac{1}{8}$in. to $2\frac{1}{2}$in., 5/6
$\frac{3}{4}$in. to 1in. 3/-		$2\frac{5}{8}$in. to 3in., 7/6
1in. to $1\frac{1}{2}$in., 3/6		$3\frac{1}{8}$in. to $3\frac{1}{2}$in., 9/6
$1\frac{5}{8}$in. to 2in., 4/6		$3\frac{5}{8}$in. to 4in., 11/6

Equalise the strain, and are generally more useful than ordinary carriers.

"ONCE TRIED, ALWAYS USED."

When the Lathe has not a Clement's Driver, a stud in the face-plate is required.

The smaller sizes can be sent per parcel post at 3d. to 6d. extra.

NOTICE.

THE BRITANNIA COMPANY are always designing **NEW TOOLS.** If you do not see what you require in their Catalogue, write to

BRITANNIA WORKS, Colchester,

giving full details.

APPLIANCES FOR LATHES.

Most of the foregoing **LATHES** can be made with Hollow Mandrels drilled about 5 inches up, if desired, at from 10/- extra; or hole quite through, from 20/- extra.

If with extra hardened finished Mandrels & collars, extra, 30/-.

SELF-ACTING SCREW-CUTTING LATHES can be fitted for Self-acting Surfacing also, either from the Leading Screw (in small sizes) or by Back Shaft (in larger sizes), at from £2 10s. extra.

BORING COLLARS

For ...	3in.	4in.	4½in.	5in.	6in.	7½in.	9in.	10in.	12in. centre.
Price ...	15/-	17/6	20/-	25/-	30/-	37/6	45/-	50/-	55/-
BACK STAYS,	10/-	12/6	12/6	12/6	15/-	20/-	25/-	30/-	35/-

DIVISION PLATES can be fitted to any of the foregoing Lathes, either to Single or Double-Geared Headstocks, and with one, two, three, four, or more circles of holes, including Spring Index Point, at from 10/- to 60/- extra; about 5/- per 100 holes.

ORNAMENTAL SLIDE RESTS, from £6 10s. each.

Ditto TOOL CUTTER RECEPTACLE, 15/-. Cutters, 1/6 each.

ECCENTRIC CUTTING INSTRUMENTS, from £3 10s. each.

ORNAMENTAL CUTTERS for above, 18/- to 24/- per dozen.

DRILLING INSTRUMENT, for Ornamental Work, from £1 10s.

ORNAMENTAL DRILLS, for above, 1/6 and 2/- each.

VERTICAL CUTTING INSTRUMENT, for Wheel Cutting, Fluting, Slotting, Nicking Heads of Screws, £4 4s., Cutters for ditto 10/- each.

ECCENTRIC CHUCKS, with Ratchet Wheel and Detent, Rectilinear Slide and Screw, Ratchet Nose, at £8, £12, and £15, according to size and construction.

OVAL CHUCKS, at £9, £12 10s., and £16, according to size and construction.

GEOMETRIC CHUCKS, from £25 to £90.

ORNAMENTAL OVERHEADS, as No. 13, from £4 4s. As Lukin Lathe, from £5 5s.

Ditto DRILL SPINDLES, from 30/-

Metal Spinning can be done on almost all our Lathes. See our Lathe Book, page 139.

LATHE HEADSTOCKS,

Of superior quality, new designs, as shown on our Lathes. Complete with Face and Catch Plates, Hand Rest, and Two Tees.

Under 3½in. have no Face Plate. Face Plates are charged extra for Lathes under 3½in.

Price.	2½in.	3in.	3½in.	4in.	4½in.	5in.	6in	7½in.	9in.	10in.	12in.
Single geared	25/-	35/-	70/-	80/-	90/-	100/-	120/-	160/-	200/-		
Back geared			70/-	110/-	125/-	140/-	150/-	190/-			
Extra strong								260/-	290/-	330/-	450/- 600/-

Extra hard steel Mandrel and Collars from 30/- extra.

Lathe Castings in Rough or Part Finished.

STRAIGHT LATHE BEDS.

Catalogue No.	Length. Face. Depth.	Price of Castings in the Rough.	Price Machine Planed.	Gap Beds in the Rough.	Gaps fitted in and Planed.
	Ft. In. In. In.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
6	0 20 by 2 by 2	0 3 6	0 5 6	—	—
2	2 0 ,, 2 ,, 2	0 6 0	0 9 0	—	—
3	2 6 ,, 2½ ,, 2⅛	0 7 6	0 11 6	0 10 6	1 1 0
4	3 0 ,, 4⅜ ,, 3⅝	0 13 0	1 6 0	0 18 0	2 0 0
4	3 6 ,, 4⅜ ,, 3⅝	0 15 0	1 10 0	1 0 0	2 5 0
5	4 0 ,, 4⅝ ,, 4⅜	1 0 0	1 17 0	1 7 6	2 15 0
5	5 0 ,, 5¼ ,, 5¼	1 10 0	2 15 0	2 0 0	3 15 0
5	6 0 ,, 5¼ ,, 5½	1 15 0	3 2 6	2 5 0	4 5 0

SCREW-CUTTING LATHE BEDS, WITH GAPS.

Catalogue No.	Length.		Face.	Depth.	Price of Castings in the Rough.			Price with Gaps fitted in and Planed.		
	Ft.	In.	In.	In.	£	s.	d.	£	s.	d.
13	2	6	by 3½	by 3	0	18	0	2	0	0
13	3	0	,, 3½	,, 3	1	0	0	2	5	0
15	4	0	,, 6⅛	,, 4⅜	1	10	0	3	0	0
16	5	0	,, 7⅛	,, 5½	2	5	0	4	10	0
16	6	0	,, 7¼	,, 5½	2	12	6	5	5	0
17	6	0	,, 8¾	,, 6	3	7	6	6	0	0
17	7	0	,, 9	,, 7	4	7	6	8	0	0

Slightly Imperfect Casting we sell at 3-4ths above Prices.
Larger Lathe Beds up to any Size to Order

LATHE DRIVING-WHEEL CASTINGS.

	For Gut.						For Flat Belt.			
Diameter	14in.	18½in.	20in.	20in.	24in.	27in.	27×1¼	27×1¼	27×1½	27×2
Weight	17lb.	28lb.	36lb.	59lb.	82lb.	124lb.	113lb.	130lb.	125lb.	183lb
No. of Speeds	3	2	4	4	4	5	3	4	3	4
Price in Rough	3/-	4/9	6/-	10/-	14/6	21/-	19/-	22/-	21/-	30/6
Bored and Turned	7/-	9/-	12/6	17/6	25/6	34/-	32/6	35/6	33/6	52/-

LATHE CRANK-SHAFTS.

	Single Throw.				Double Throw.			
For Lathes of Length Bed	2ft. 6in.	3ft.	3ft.	4ft.	4ft.	5ft.	6ft.	7ft.
Rough Forging	4/-	4/6	7/6	8/6	12/6	16/6	18/6	21/-
With Shaft and Dips turned bright	8/-	9/-	14/-	17/-	22/-	28/-	32/-	36/-

Anti-Friction Roller Bearings for Crank Shafts, 17/6 per pair.

CHANGE-WHEELS FOR SCREW-CUTTING LATHES.

	No. 14.	No. 12.	No. 10.	No. 8.	No. 7.	No. 6.
Pitch	3/16in. full	¼in. full	5/16in.	⅜in.	7/16in. full	½in. full
In Rough	12/6	16/6	30/-	50/-	70/-	95/-
Bored and Turned, and Key Ways Cut	30/-	37/-	51/-	67/-	85/-	108/-

COMPOUND SLIDE-REST CASTINGS.

For Lathes of Height Centre	2in.	2½in.	3in.	3½in.	4in.	4½in.	5in.	6in.	7in
Price, Rough	2/3	2/3	2/9	4/-	5/6	6/9	11/-	13/-	—
,, Planed	6/-	6/-	9/-	11/6	16/-	18/6	22/-	30/-	38/-

☞ *Cut Gear Wheels, of any Size, to Order.*

CASTINGS FOR

LATHE HEADSTOCKS and RESTS.

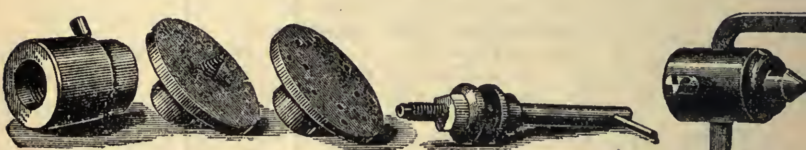
Catalogue No.	Height of Centre Inches.	Component Parts of Sets.	Price in the Rough. £	s.	d.	Do., Heads Bored and Planed. £	s.	d.
		SINGLE-GEARED.						
2	2½	Headstock, Cone Speed, Driver Chuck, Poppet, Hand Wheel, Cap, Barrel and Screw, Mandrel, Cast Steel for Centres, Holding-down Plates, Hand Rest, and Two Tees ...	0	10	0	0	14	0
3	3	Do. do. and Locking Handle	0	12	0	0	17	0
4	3½	Do. do. and Face and Catch Plates	1	5	0	1	14	0
4 or 5	4	Do. do. do. do.	1	7	6	1	17	6
4 or 5	4½	Do. do. do. do.	1	10	0	2	1	0
4 or 5	5	Do. do. do. do.	1	15	0	2	7	0
5	6	Do. do. do. do.	2	5	0	2	19	0
		BACK-GEARED.						
3	3	Headstock, Cone Speed and Pinion, two Gear Wheels and Pinion, Catch Plate, Poppet, Hand Wheel and Handle, Cap, Barrel and Screw, Back Cone, Locking Handle, Gear Knob and Bolt, Mandrel, Tail Pin, Cast Steel for Centres and Back Shaft	0	15	0	1	1	6
4	3½	Do. do. and Face Plates and Gunmetal Bushes	1	10	0	2	0	0
4 or 5	4	Do. do. do. do.	1	15	0	2	7	0
4 or 5	4½	Do. do. do. do.	2	0	0	2	13	0
4 or 5	5	Do. do. do. do.	2	5	0	2	19	0
16	5	Do. do. do. Gut Speed	3	3	0	3	19	0
16	6	Do. do. do. do.	3	7	6	4	3	6
16	5	Do. do. Flat Speeds with Eccentric Back Barrel and Shaft	3	7	6	4	4	0
16	6	Do. do. do. do.	3	10	0	4	6	6
17	6	Do. do. do. do.	5	17	6	7	7	6
17	7	Do. do. do. do.	6	10	0	8	2	0

We sometimes have slightly defective sets at ¾ prices.

USEFUL LATHE CHUCKS, &c.

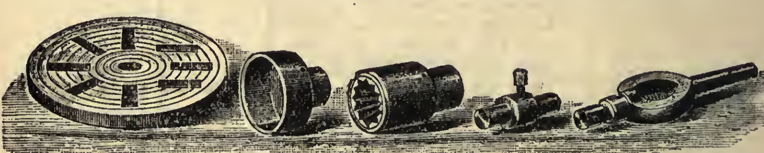
1 2 3 4 5

No.		£	s.	d.
1	Pronged Chuck, for wood, ⅝in. shank	0	2	6
2	Cross or Four-blade Chuck, for hard wood, ⅝in. shank	0	3	0
3	Square Tapered-hole Chuck, to suit ordinary brace-bits, ⅝in. shank ..	0	3	0
4	Solid Gunmetal Chuck, ⅝in. shank, face left solid and plain to turn to requirements	0	1	6
5 & 6	Main Chuck, turned and tapped to fit nose of mandrel, and with ⅝in. hole at other end to receive the "Essex" or other small chucks 5s. and	0	7	6



6 7 8 9 10

7	Flange Chuck, 2in. diameter, with taper screw for wood	0	6	0
	Ditto, 4in. diameter	0	7	6
8	Flange Chuck, for attaching flat wood to, bored and tapped to fit mandrel nose, and drilled, countersunk at back, 3in. diameter ..	0	5	0
	Ditto, ditto, 6in. diameter	0	7	6
9	Mandrels, with screw collars for holding saws or emery wheels, 6in., 6s.; 8in., 8s.; 10in., 10s. 6d.; 12in., 12s. 6d.			
10	Driver Chucks .. .. 5s. and	0	7	6



11 12 13 14 15

11	Face Plates : 6in., 10s.; 8in., 15s.; 12in., 20s.; 16in., 30s.; 18in., 35s.			
12	Gunmetal Cup Chucks, of various diameters, ¾in., 2s. 6d.; 1in., 3s.; 1¼in., 4s.; 1½in., 5s.; 2in., 6s. 6d.; 2½in., 8s.; and 3in., 10s. each The set	1	19	0
13	Self-centreing Chuck for wood, with conical hole, ribbed longitudinally 5s. and	0	7	6
14	Drill Chuck, ⅜in. hole, with set screw and extra plug for small drills, ⅝in. shank	0	4	6
15	Lathe Carriers, steel screws, turned shanks, ⅜in., 1s. 4d.; ½in., 1s. 8d.; ¾in., 2s.; 1in., 2s. 6d.; 1¼in., 3s.; 1½in., 3s. 6d.; 1¾in., 4s. 6d.; 2in., 5s.			

Square, Half-round, and Female Centres, from 1s. 6d. to 2s. 6d. each.

Chucks and Appliances for Special Work Made to Drawing.

USEFUL LATHE APPLIANCES.

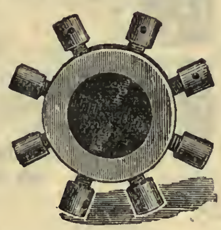
BRITANNIA  DIE CHUCK.

IS SIMPLE, DURABLE, AND REMARKABLY CHEAP.

Unlike Scroll Chucks, they can be used either concentric with, or eccentric to, the Lathe centre. They have back plates with plain hole, ready for screwing to fit any Lathe. They have a wide range of work, and, from their simplicity of construction, are free from liability to get out of order.

Diameter.	Size of Lathe to suit.	Range.	Price
$2\frac{1}{4}$in.	$2\frac{1}{2}$in. to $3\frac{1}{2}$in.	$\frac{3}{16}$in. to $\frac{1}{2}$in.	10/6
$4\frac{1}{2}$in.	4in. to 6in.	$\frac{1}{4}$in. to 1in.	15/-

Fitting to Lathe, extra, 2/6.

BELL  CHUCKS.

Outside diameter.	Inches—2	3	4	5	6	7	$7\frac{1}{2}$	10
Four Screws	14/-	15/-	17/6	22/6	25/-	32/6	38/-	50/-
Eight Screws	14/-	18/-	22/-	25/-	30/-	38/-	45/-	60/-

Oval, Eccentric, and Ornamental Chucks, made to order.
Ornamental Rests, Drill Spindles, Cutters, &c.

Screw Chasing Tools, internal and external, price per pair, handled, from 40 to 12 threads per inch, 3/-; from 11 to 6 threads per inch, 4/-

Taps, Taper or Plug,

Size	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	inch.
Price	2/-	2/-	2/-	2/6	2/6	3/-	4/-	5/-	7/-	8/-	9/-	each.
Boring Bars			2/6	3/-	3/-	4/-	5/-	each.		Cutters, 6d.		each.
Swivel Cutter Bars			4/6	5/6	5/6	7/-	8/6	,,		,,		,,

Plain Drills, 2d., 3d., 4d., and 6d. each. Milling Wheels, with Handles, 2/- each.

Circular Saws, 2in. 2/6; 3in. 3/-; 4in. 3/6; 5in. 5/6; 6in. 6/-; 7in. 7/-; 8in. 8/- each.
Platforms for ditto, with adjustable Tables, 6 by 8, 12/6; 8 by 12, 15/-

Mandrel with Screw Collars for Holding Saws or Emery Wheels, 6/- and 8/- each.

Grindstones, with Troughs, for fixing on above Mandrels,
4in. 3/6; 5in. 4/-; 6in. 5/-

Emery Wheels, 3in. 1/- and 3/2; 4in. 2/- and 4/-; 6in. 3/3 and 4/6.
Buff Polishing Wheels, 3in. 1/-; 4in. 2/-

Best Polishing Brushes, 1/- each. Bobs, 2/- Wire Polishing Brushes, 1/-, 1/6, 2/-, 2/6 each.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

THE ESSEX CHUCK.

To take up to ¼in. Drills	10s.
Size larger, to take ½in. Drills	25s.

Made of Steel throughout.

A CHEAP AND DURABLE CHUCK.

J. K. P. CHUCK.

50s.

Extra jaws, 10s.

Holds Tighter.

Wears Longer.

Holds Irregular Forms as well as Regular.

Can be set Eccentric.

With the Jaws as Fixed it Holds Drills $\frac{5}{64}$ to $\frac{27}{64}$.

1B Die Holds Articles $\frac{11}{16}$ to $1\frac{11}{16}$.

Die 1A is made to hold to ½, ½ to ¾, ¾ to 1-inch.

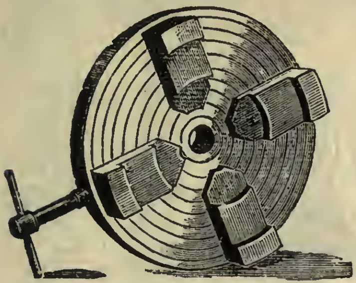
Special Jaws made to Suit Special Jobs.

BRITANNIA Co. have much pleasure in recommending the above Chuck. It offers many advantages, which will be obvious to experienced Mechanics.

PRICE, £2 10s. with one set of Jaws; 10s. per pair for extra Jaws of either pattern.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

INDEPENDENT 4-JAW CHUCKS.

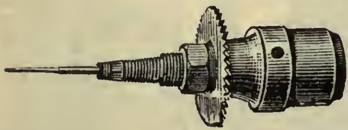


6 inch	... ...	60s.
8 ,,	... ...	80s.
9 ,,	... ...	90s.
10 ,,	... ...	100s.
12 ,,	... ...	120s.

Larger sizes, up to 20 inches diameter, per inch, 10s.

Above are extra strong, with wrought Jaws, and more durable than those generally sold.

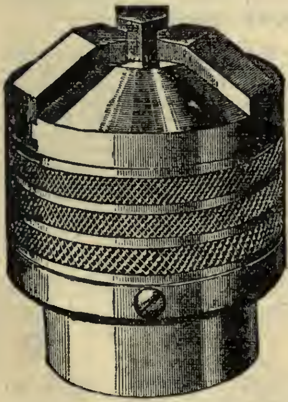
THE JEWELLER'S CHUCK



Is a valuable appliance to the mechanic or amateur. It carries drills, circular saws, polishing brushes, and polishing bobs.

Price 7s. 6d.; Saws to suit, 2s. 6d.; Polishing Brushes, 1s. 6d.; Emery Wheels, 2s. each.

WHITON'S "1883" DRILL CHUCK.



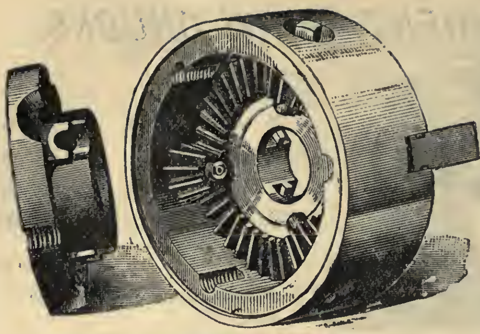
These Chucks are easily attached to any Lathe or Drill by a taper plug. All the parts are of steel, and thoroughly made.

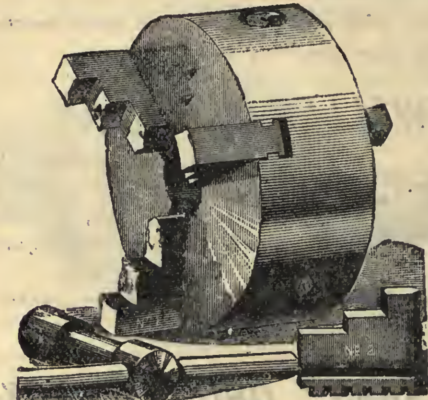
No. 1, 2in. diameter, holds Drills from 0in. to $\frac{9}{16}$in., 17s.

No. 2, $2\frac{1}{2}$in. diameter, holds Drills from $\frac{1}{64}$in. to $\frac{3}{4}$in., 21s.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

WHITON'S PATENT GEARED SCROLL CHUCK.

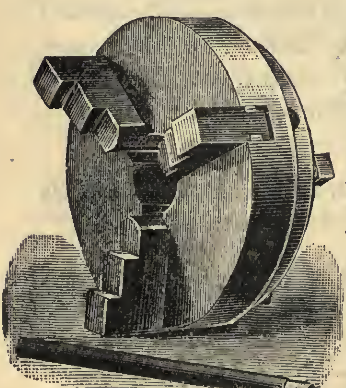




DIAMETER.	WEIGHT ABOUT.	PRICE.	DIAMETER.	WEIGHT ABOUT.	PRICE.
2½ inches.	2 pounds.	30s.	6 inches.	12½ pounds.	71s
3¼ ,,	3 ,,	42s.	7½ ,,	20 ,,	80s.
4⅛ ,,	6 ,,	50s.	9 ,,	35 ,,	92s.
5 ,,	8½ ,,	59s.	12 ,,	60 ,,	125s.

The outer shells of all chucks up to and including 5in. are of malleable iron, and the jaws, scrolls, pinions, &c., of all sizes, are of steel. The workmanship is first-class throughout. Price List includes keys and bolts. Unless otherwise ordered, these chucks are always supplied with lathe jaws. Add 10 per cent. for chucks having four jaws. Add 20 per cent. for chucks having two sets of jaws (lathe and drill).

WHITON'S IMPROVED LEVER CHUCKS.



A heavy band of wrought iron is shrunk firmly around the front plates of the larger sizes, which are thus greatly strengthened. The holes in the scroll for receiving the lever are drilled into bosses cast for the purpose, while the outer rim of the scroll between these bosses is much lighter than formerly; thus the parts of this chuck receiving the heaviest strains are made stronger than in other chucks of this class, without making them inconvenient from over weight.

The front plates of the 3in., 4in., and 6in. sizes are of malleable iron, and the scrolls and jaws of steel.

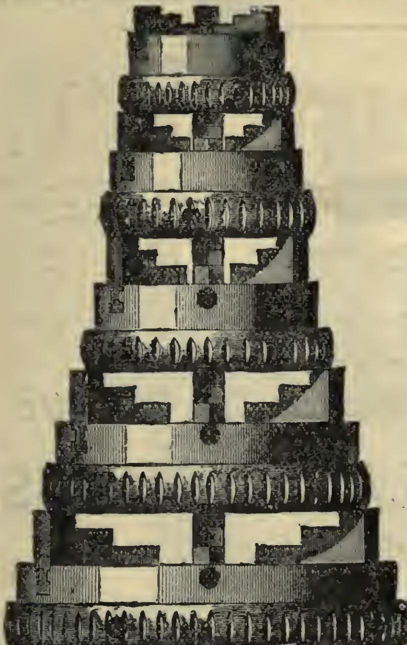
DIAMETER.	PRICE.	DIAMETER.	PRICE.
3 inches.	34s.	15 inches.	134s.
4 ,,	42s.	18 ,,	159s.
6 ,,	67s.	21 ,,	200s.
9 ,,	88s.	24 ,,	250s.
12 ,,	109s.		

Unless otherwise ordered, these chucks are always supplied with lathe jaws.

Add 10 per cent. to above List for chucks with four jaws. Add 20 per cent. to above List for chucks with two sets of jaws (lathe and drill).

WHITON'S

IMPROVED AMATEUR CHUCKS



Are very neat in design, and are intended for amateurs' use on foot and light power lathes, and for all classes of light work.

Although very light, they are strong and durable, the shell being made of malleable iron, and the scroll and jaws of steel.

They are intended for attachment by means of a face-plate.

They operate by hand or lever.

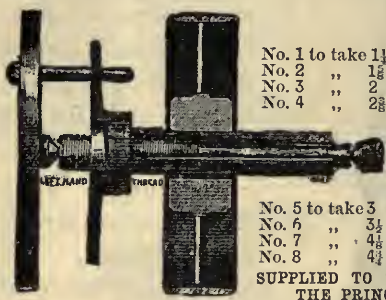
Diameter.	Weight about.	With Lathe Jaws (as shown in sketch).	With Lathe and Drill Jaws.
2 inches.	¾ pounds.	19s.	24s.
2½ "	1¼ "	21s.	26s.
3 "	1¾ "	23s.	28s.
4 "	3½ "	27s.	34s.
5 "	5 "	32s.	38s.

Above Prices include Levers and Face-Plate Screws.

When ordering chucks, it is necessary to send a chuck which exactly fits your mandrel. When chucks require fitting, an extra charge is made—usually about 10s.—for face-plate, &c.

Other American Scroll Chucks to order at usual lists.

PATENT
EXPANDING LATHE MANDREL.



PRICES:

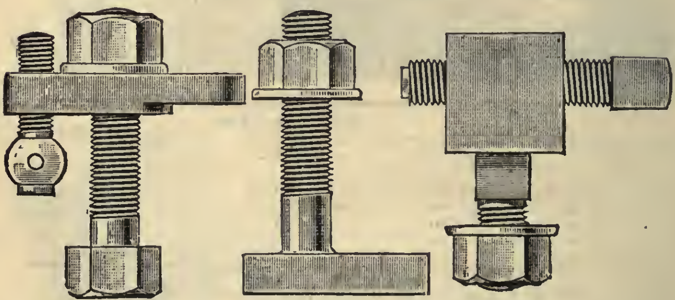
			£	s.	d.	Extra Slides.
No. 1	to take	$1\frac{1}{4}$ to $1\frac{5}{16}$ ..	1	15	0	15s.
No. 2	,,	$1\frac{5}{8}$ to $1\frac{7}{8}$ ..	1	15	0	12s.
No. 3	,,	2 to $2\frac{1}{4}$ ..	2	5	0	12s.
No. 4	,,	$2\frac{3}{8}$ to $2\frac{5}{8}$ ..	2	15	0	15s.
No. 5	to take	3 to $3\frac{3}{8}$ ..	3	15	0	15s.
No. 6	,,	$3\frac{1}{2}$ to 4 ..	4	5	0	16s.
No. 7	,,	$4\frac{1}{8}$ to $4\frac{5}{8}$ ..	5	0	0	17s.
No. 8	,,	$4\frac{3}{4}$ to $5\frac{1}{2}$ ..	5	10	0	17s.

These Mandrels are Protected, and Legal Proceedings will be taken against any Infringers.

SUPPLIED TO THE ROYAL ARSENAL AND ALL THE PRINCIPAL RAILWAY WORKS, &c.

Sole Makers: Britannia Co., Colchester.

LATHE CLAMPING DOGS
(of Various Styles).



No. 1 No. 2. No. 3 Pattern.

The above will be found very useful for securing the work to be bored or turned to the face-plate on the Lathe.

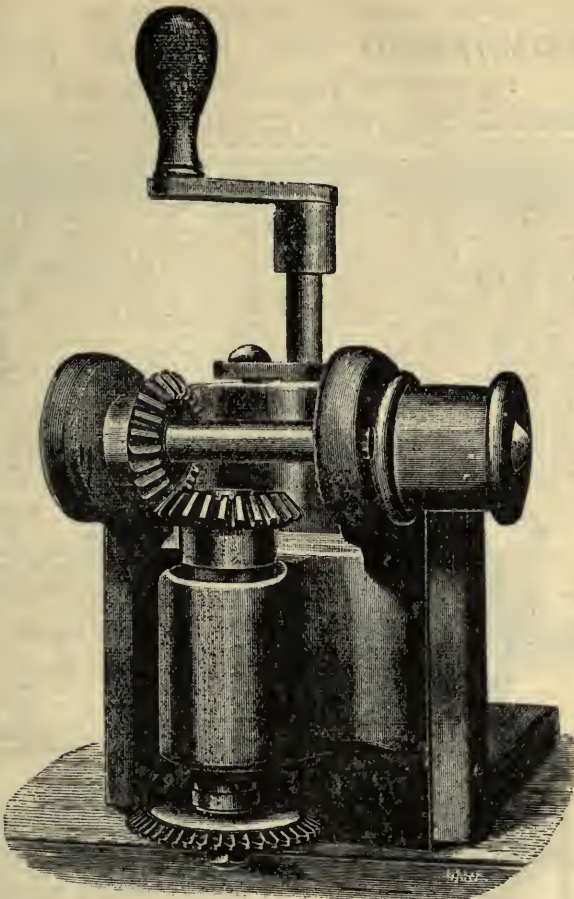
Price to suit 4in. to 6in. Centre Lathes:

Pattern No. 1, 3s. 6d.; No. 2, 1s. 6d.; No. 3, 4s. each.

OTHER SIZES AND PATTERNS MADE TO ORDER.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

GEAR CUTTER FOR LATHE.



By BRITANNIA COMPANY, COLCHESTER.

The above Illustration shows the new Gear Cutter, which can be fitted upon the slide-rest of any lathe, and the cross and parallel slides are thus utilised to give the necessary traverse; or it can also be fixed upon a tool-post.

It is driven from an overhead pulley. The milling cutters are held on the spindle by the nut and washer. A vertical slide gives the necessary vertical traverse.

This is a most useful adjunct to the lathe for fluting taps, milling key-ways, spiral fluting, cutting bevel and worm wheels, &c. Wheels with any number of teeth can be accurately cut by means of a division plate. This has hitherto been an expensive appliance, but the Makers have brought them within the reach of the amateur, who will, by its assistance, be able to accomplish many jobs hitherto quite beyond his reach. The price is **£4 4s. 0d.**, adapted for lathes up to 6in. centres.

OVER 10,000 OF THESE VICES IN USE.

INSTANTANEOUS GRIP PARALLEL VICES.

The First Cost Saved in Twelve Months.

Although one of the most noticeable features of the present day is the extent to which labour-saving appliances have been successfully introduced, yet it may safely be said that in no branch has less progress been made than in Vices, articles which are so commonly in use everywhere. The old screw vice is still to be found in every workshop, large or small, and were it possible to estimate the amount of time spent in a twelvemonth in the repeated screwing-up and unscrewing it would show a great amount of misdirected energy and a startling amount of wasted time. Fig. 1 represents one of the Engineers' Vices with instantaneous grip. These Vices are invaluable in enabling a man to fasten INSTANTLY any size of work. By raising the handle to a vertical position the Sliding or Loose Jaw is at liberty to be moved, and can be adjusted at once to any thickness of article within the scope of the Vice. The work is held in one hand, and the loose jaw is, with the other hand, pushed against the work, and BY HALF A TURN OF THE HANDLE INSTANTLY FASTENED, ALL SCREWING BEING ENTIRELY DISPENSED WITH. THESE VICES WILL STAND ANY AMOUNT OF HARD USAGE. THE GRIP IS CERTAIN and cannot relax, and from the fewness of working parts it is almost an impossibility for them to get out of order.

The Racks are made of a Special Steel, suitably hardened, and as they MERELY ENGAGE WITHOUT RUBBING, will last an indefinite length of time. The method of fixing the loose Steel Jaws is also a great improvement over that adopted in ordinary Parallel Vices. They are easily removable at any time, which makes the cost of re-cutting trifling, compared with that of Wrought Vices.

The Vices can be swivelled round to any position on the bench, and are therefore particularly adapted for many classes of work otherwise bad to get to a Vice. They can be easily removed from one bench to another by taking off the wing nut and the screws. They can always be kept clean without trouble, as five seconds suffice to take one to pieces. No workshop ought to be without them. The whole first cost is saved in twelve months in economy of time, and through requiring no repairs.

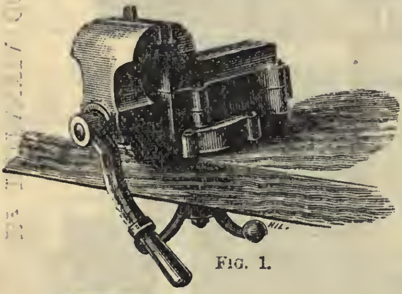


FIG. 1.

ENGINEERS' VICES.

In various sizes and styles, for Engineers, Machinists, Founders, Gunmakers, Blacksmiths, Sewing Machine-makers, Brass Finishers, Amateurs, Jewellers, Dentists, &c.

BENCH VICES.

No.		£	s.	d.
0 E, 3in. Jaws, to open	3in.	1	7	6
01 E, 3¾in. ,, ,, ,,	4in.	1	12	0
1 E, 5in. ,, ,, ,,	5in.	1	18	0
2 E, 6in. ,, ,, ,,	6½in.	2	5	0
3 E, 7in. ,, ,, ,,	8½in.	3	5	0

Nos. 1, 2, and 3, are same pattern as shown.

N.B.—These Vices, from 5in. Jaws and upwards, are supplied with Fast Handle, as shown in Fig. 1, except specially ordered with long, Loose Handle, as shown in Fig. 2. For ordinary work, and particularly where there is much changing in and out of the Vice, the Fast Handles are certainly preferable, the Loose Handle only being recommended for very heavy work.

For general work, Nos. 2 E and 3 E Vices are particularly recommended.

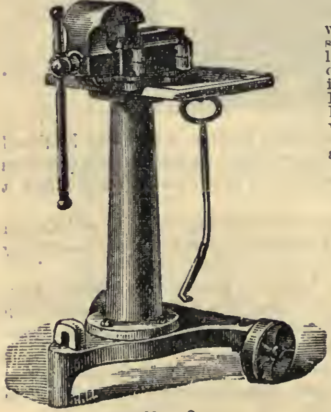


FIG. 2.

PLANING MACHINE VICES.

		£	s.	d.
No. 6 E, 5¼in. Jaws, to open	6½in. ..	3	15	0
,, 7 E, 6in. ,, ,,	8½in. ..	4	15	0
,, 8 E, 9in. ,, ,,	8½in. ..	5	10	0
,, 9 E, 12in. ,, ,,	8½in. ..	6	10	0

PORTABLE VICES.

		£	s.	d.
No. 2 S, 6in. Jaws, to open	6½in. ..	4	15	0
,, 3 S, 7in. ,, ,, ,,	8½in. ..	6	0	0

SPECIAL PRICES.

Twist Drills with Straight Shanks.

	$\frac{1}{16}$	$\frac{3}{32}$	$\frac{1}{8}$	$\frac{5}{32}$	$\frac{3}{16}$	$\frac{7}{32}$	$\frac{1}{4}$
	4d.	5d.	6d.	7d.	8d.	10d.	1/2
$\frac{9}{32}$	$\frac{5}{16}$	$\frac{11}{32}$	$\frac{3}{8}$	$\frac{13}{32}$	$\frac{7}{16}$	$\frac{15}{32}$	$\frac{1}{2}$
1/3	1/4	1/7	1/11	2/1	2/3	2/5	2/8
$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1in.
3/9	4/8	5/6	6/4	7/7	8/8	9/10	11/-

☞ *We supply First-class Quality at two-thirds above Prices. Sent Post Free to any part of England. Similar reduction on Taper Shanks, which are higher priced.*

For Forges, Anvils, Vices, Bellows, &c, supplied at Makers' Prices, *see* New Catalogue.

DRILLING, Shaping, Planing Machines, Circular Saw Benches, etc., etc., if of good design and fair condition, are taken in exchange for larger or better Tools, and these we offer in our Monthly Tool and Machinery Register, Free by Post for 4d.

LARGEST STOCK IN LONDON.

Britannia Co. } 100, HOUNDSDITCH, London.

Four Minutes' Walk from Broad St. and Liverpool St.

All Letters to Britannia Co., Colchester, England.

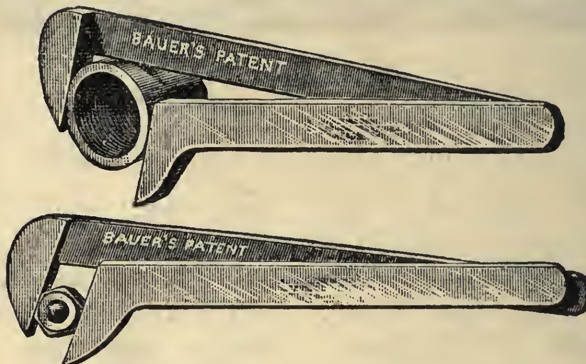
TERMS—CASH, OR HIRE-PURCHASE.

SELF-ADJUSTING, SELF-GRIPPING, AND SELF-ACTING

Link Spanner and Pipe Wrench.

FOR BOLTS, NUTS, TUBES, GAS PIPES, &c., &c.

The Best and Cheapest.



Many Thousands in Use.

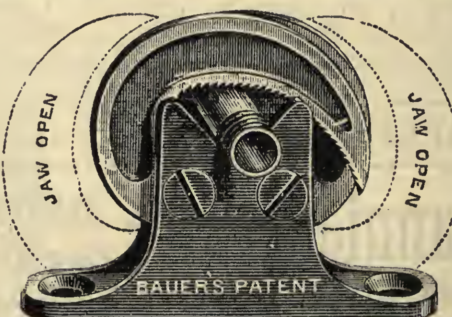
5in.	8in.	12in.	15in.	18in.	24in.
1s. 8d.	2s. 8d.	4s.	5s.	6s.	8s.

It is made entirely of steel, and acknowledged to be the best shifting spanner ever seen; also the best pipe wrench, as it grips from the smallest to the largest size instantly.

INSTANTANEOUS SELF-ADJUSTING AND SELF-ACTING

TUBE AND BOLT VICE.

No. 1 holds $\frac{1}{4}$in. to $1\frac{1}{4}$in. Tubes, &c. 7s. 6d.

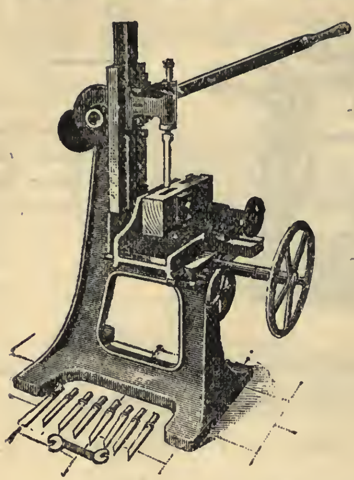


No. 2 holds $\frac{1}{4}$in. to $2\frac{1}{2}$in. Tubes, &c. 15s.

This is the handiest and best, as it grips automatically, and works in any position. It weighs only about one-fifth of the old-fashioned cast-iron Tube Vices.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

The Britannia Mortice Machine.



We have put into this Machine all the additions and improvements that many years' experience suggests.

Many of our Mortice Machines are working various kinds of wood, to the satisfaction of the users, in all parts of the world.

IN designing and constructing the above Machine our great aim has been to make a MORTICE MACHINE at an exceedingly low price, and which for simplicity, efficiency, and accuracy in all its working parts, cannot be surpassed.

It is suitable for working either hard or soft wood, thus making it a most acceptable machine for all classes of Joiners, Builders, Cabinet Makers, &c., &c.

The Frame itself is made in one casting. By this means a strength and solidity is given to the machine which is not only very desirable, but very necessary where good work is required to be done.

The wrought-iron Lever which is used for bringing the chisel down to its work is so placed that, when the workman is using the machine, he stands in an easy and convenient position for operating on and seeing the work he is doing.

The Chisels are made at the works, under our own supervision, from a high-class steel specially manufactured for morticing purposes.

Each chisel is fitted with a pin which fits in a slot hole in a taper socket in chisel box; this keeps it immovable, and perfectly true in reversing; thus, by half-turn of chisel box handle the chisel is reversed truly.

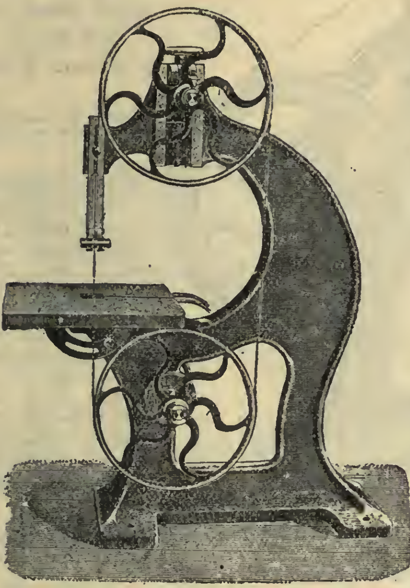
This Machine will mortice 6in. deep, and take work on the movable table 15in. by 8in. Weight of machine, 3cwt. 3qrs.; with Boring Apparatus, 4cwt.

Price of Machine, including 8 chisels, ¼in. to ¾in., one spanner, and one core-driver (without Boring Apparatus)	£8
Price of Machine with Boring Apparatus, including three bits for iron and three for wood	£9
Self-coring Chisels, extra	10s.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

IMPROVED 24in.

BAND SAW MACHINE.



THIS illustration represents the smallest size of Endless Band Saw Machines we make for working by steam power. It will be a most useful addition to the works of builder, cabinet maker, joiner, wheelwright, or pattern maker, &c. It occupies little space, and requires but a small amount of power to work it.

The main standard is a plain but very strong casting, of neat design, and made and shaped in such a manner as to give a great amount of space between the saw and the frame; this being a great desideratum in a machine of this class.

The table is planed on the surface, and is fitted with a canting arrangement, so that work may be sawn at any required angle.

The band-saw pulleys are bored and turned, and then carefully balanced, so as to ensure steadiness in working. The face of each pulley on which saw works is covered with tyres, made of the best rubber, this being found to be the best substance for the purpose.

The top pulley is made to cant, and fitted with hand-wheel and screw arrangement for raising or lowering it, to suit various lengths of saws; it is also fitted with a compensation spring, to meet any expansion or contraction of the saw whilst working.

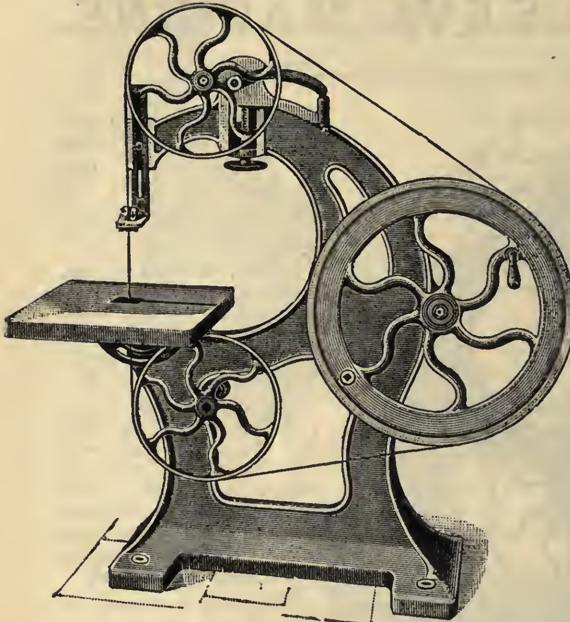
The saw blade is sustained against the pressure of sawing by two steel wheels, one of which is placed above the table, and the other immediately below the table. ... ...

The machine is fitted with fast and loose driving pulleys, striking gear, and spanners complete. ... ...

Weight about ....8cwt.	Will cut in depth ....12in.
Average power required....½-horse.	Size of Driving Pulleys 10in. by 3in.
Diameter of Saw Pulleys......24in.	Speed of ditto ......300 revolutions
Size of Table...........24in. square	**Price......................£18**

BRITANNIA WORKS, COLCHESTER, ENGLAND.

The Improved Band Saw Machine.



The above represents a useful Band Saw for Hand or Steam Power.

It is strongly built, the pillar being one solid casting; it is compact and complete in itself, occupies little room, and works by hand with greater ease than any other hand machine of its class. We introduce it to the trade with full confidence in its working, feeling certain it will not fail to give satisfaction.

It is fitted with tension motion to allow for expansion or contraction of saw whilst working. The table is made to cant for cutting work on the bevel. It will admit of work 11in. deep.

When worked by steam power, speed of driving pulleys should be about 100 revolutions per minute.

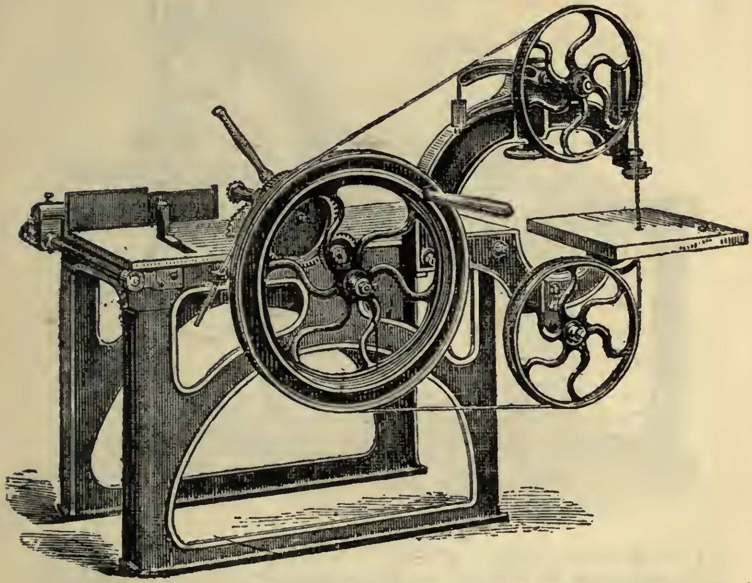
No. 1 Size, with band saw pulleys, each 16in. diameter, and fly-wheel 28in. diameter, with angle bracket for tenoning, one screw-key, and one ⅜in. saw, sharpened and set ready for use. Weight, 5cwt. 2qrs. ... ... Price	£10	10	0
No. 2 Size, with band saw pulleys each 20in. diameter, and fly-wheel 32in. diameter, with angle bracket for tenoning, one screw-key, and one ⅜in. saw, sharpened and set ready for use. Weight, 7cwt. ... ... Price	13	10	0
A Boring Apparatus, with 1in. auger, may be attached to either machine ... ... Price extra	2	0	0
Either machine may be made so as to work by steam power, by placing a pair of pulleys behind fly-wheel, one pair 9in. pulleys ... ... Price extra	0	12	6
One pair 12in. pulleys ... ... ,,	0	15	0
Belt, fork, and striking gear for ditto ... ... ,,	0	12	0

BRITANNIA WORKS, COLCHESTER, ENGLAND.

HAND POWER COMBINED

Circular & Band Sawing Machine.

For the use of Joiners, Builders, Cabinet Makers, Coach Builders, &c. It is also very useful for Contractors, as it is readily moved from place to place where required.



. The table for above Bench is 4 feet by 2 feet, substantially made of iron, planed true on top. It is fitted with Rising and Falling Spindle, Self-acting Feed Motion; Parallel Fence, made to cant so as to cut bevels, and also to turn over end of bench, to be out of the way of cross cutting. It is also fitted with Weight and Roller for keeping timber to Fence.

With this Bench one man can cut three inches deep at the rate of ten feet in four minutes, or two inches deep at the rate of ten feet in two minutes, thus effecting a saving of 150 per cent. over what can be done with the Hand Saw.

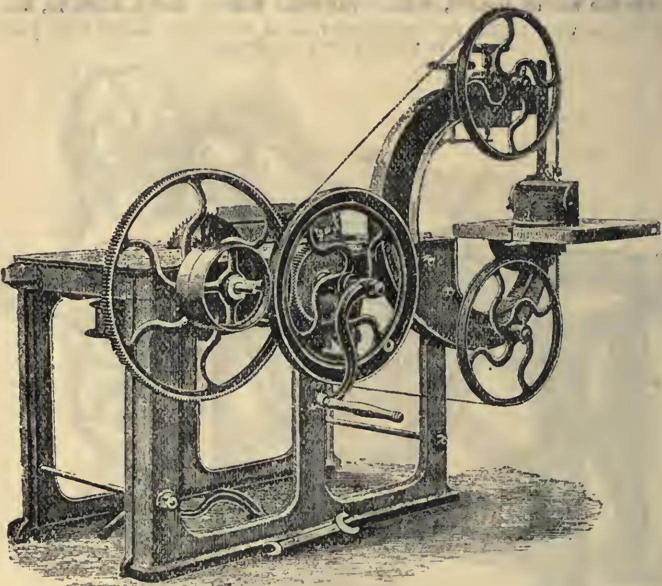
Band Saw Apparatus is fitted with square table, made so as to cant over for cutting to any bevel. With this may be cut any irregular, curved, or ornamental design, with an ease not attained before by any Hand-power Machine. The Band Saw is fitted with a new arrangement for securing equal tension to saw at all times.

Price of above Machine, with one each 9in. and 14in. Circular and one $\frac{3}{8}$-inch Band Saw, for Hand and Steam Power...	£24	0	0
Ditto if with Boring Apparatus and one Auger ....extra	2	0	0
Ditto if for Steam Power only and not for Hand	23	10	0
Ditto if for Hand Power only	22	0	0

BRITANNIA WORKS, COLCHESTER, ENGLAND.

THE COMBINATION HAND POWER

Circular & Band Sawing Machine.



THE above hand-power machine is fitted with two handles, one on each side of machine; by this arrangement when requisite, two men may be turning at the same time without being in each other's way. It can also be fitted with fast and loose pulley to work by steam power.

It is specially adapted for joiners, builders, cabinet makers, and other workers in wood.

Saw spindle is made to rise and fall for rabbeting and grooving purposes. Parallel fence is arranged so as to cant to any angle, for cutting work on the bevel. Table is 4ft. by 2ft. planed true on the surface. A self-acting feed arrangement brings the work up to the circular saw. A boring apparatus can also be attached to the bench, as shown above.

Size, to take a circular saw 15in. diameter, to cut 5in. deep, and with the band-saw 6in. deep; approximate weight, 9cwt.; size of driving pulleys if fitted with steam power, 7in. by 2¼in.; speed of driving pulleys if fitted up for steam power, 100 revolutions.

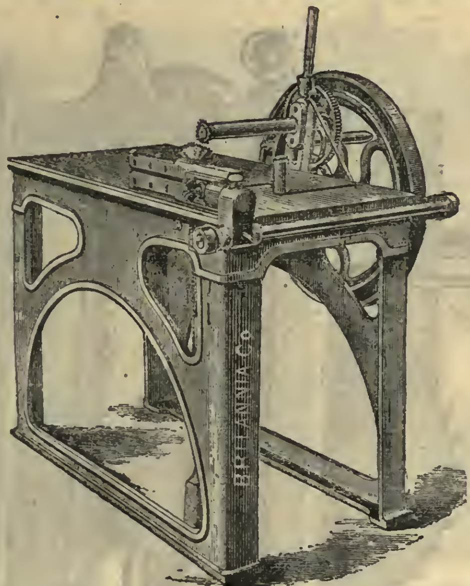
With one each 9in. & 15in. circular saw, and one ⅜in. band saw...	£24
Bench, without band-saw apparatus, with one 15in. and one 9in. circular saw............	14
If with boring apparatus and one ½in. auger, extra	2
If with fast and loose pulley, 7in. by 2½in., for steam power, extra	1

For larger sized Saw Benches and for Steam-power Circular Saw Benches see Catalogue.

IMPROVED HANDPOWER

CIRCULAR SAW BENCH

For the use of Joiners, Builders, Cabinet Makers and Couch Builders.



It is also very useful for Contractors, as it is readily moved from place to place where required.

THE above Bench, 4ft. by 2ft., is substantially made of iron, planed true on the top. It is fitted with rising and falling spindle, self-acting feed motion; parallel fence, made to cant, so as to cut bevels, and also to turn over end of bench, to be out of the way of cross cutting. It is also fitted with weight and roller for keeping timber to fence.

With this Bench one man can cut 3in. deep at the rate of 10ft. in four minutes, or 2in. deep at the rate of 10ft. in two minutes, thus effecting a saving of 150 per cent. over what can be done with the hand-saw.

Size.—Will cut with a 14in. saw 4½in. deep, and with the band-saw 6in. deep. Approximate Weight with 6 rollers for extending the bench, 6cwt. 2qrs.

The above may be worked by steam power by replacing the flywheel with pulleys for belt driving. It can be fitted with boring apparatus if desired.

	£	s.	d.
Price (including 2 circular saws, viz., 9in. and 14in., 6 rollers and carriers for extending the Bench, and 2 extra change wheels for feed motion)	12	10	0
Ditto (if without feed motion, and without rollers and carriers for extending the Bench)	10	10	0

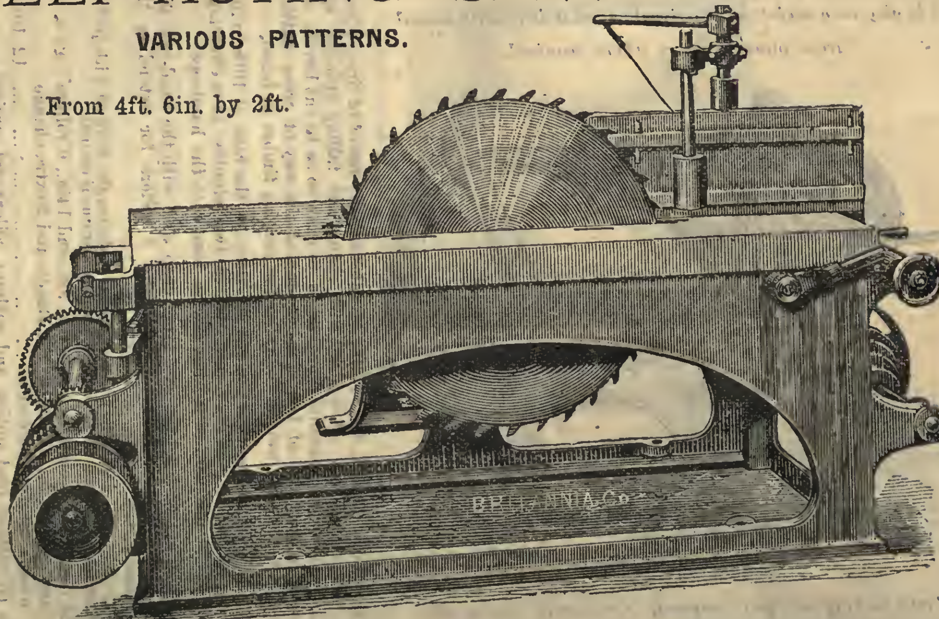
For an extra charge of 10s., this Bench can be prepared to work either by steam or hand, as occasion requires.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

SELF-ACTING SAW BENCHES.

VARIOUS PATTERNS.

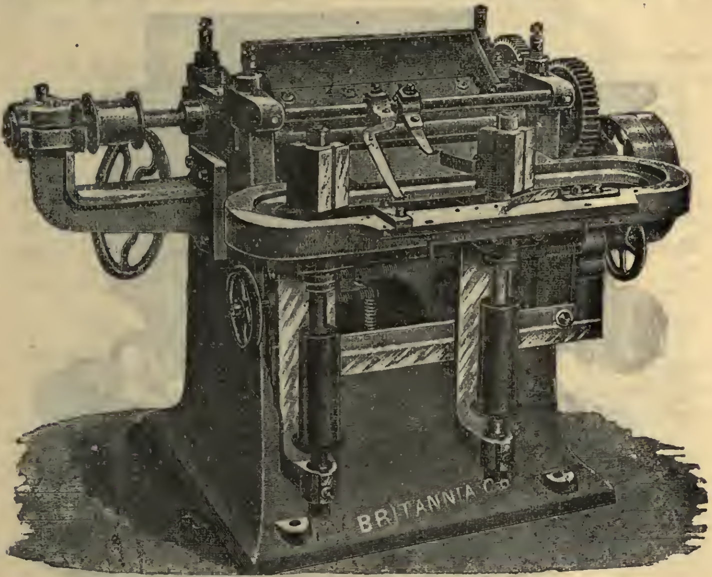
From 4ft. 6in. by 2ft.



THESE Benches are useful for cutting planks or battens into boards or scantlings. The tops are planed true on the surface; and are fitted with strong parallel fence, to which is attached pressure lever and roller for keeping timber to fence whilst being sawn into boards, &c.

BEST CAST STEEL CIRCULAR SAWS AT LIST PRICES.

COMBINED PLANING, THICKNESSING, AND MOULDING MACHINE.



THIS machine is an improvement on the Panel Planing and Thicknessing Machine, and is designed with a view to meet the demand for a machine that will occupy but a small space, and yet be as efficient in its working as a large machine.

It will surface and thickness up stuff from ⅛in. to 5in. in thickness, and it will plane work on three sides at one operation up to 18in. wide and 4in. thick.

It will plane, joint, tongue, and groove, work skirtings, strike mouldings, work window and sash bars, and will be found a most valuable machine for joiners, carpenters, cabinet-makers, pattern-makers, &c.

The side adzes are of steel, and work in long gun-metal bearings. The cutter blocks are wrought iron, and fitted loose on spindles, so as to be removed when required.

The brackets for carrying the spindles are made very strong, and can be adjusted by means of hand wheel and screw on each side of machine, to suit the various widths of work to be done.

The feed rollers and gearing are of wrought iron, very powerful and effective. Three rates of feed to suit various thicknesses.

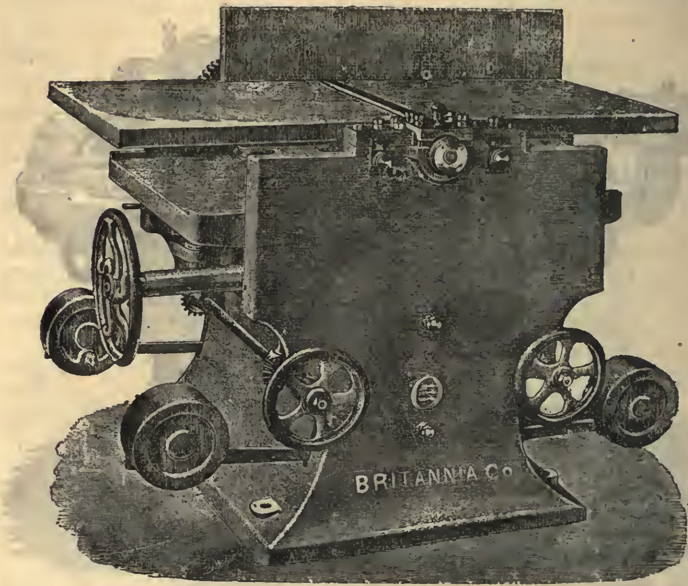
The machine is complete with countershaft, spanners, lubricators, &c.

Sizes.	To work stuff on three sides at one operation.	Approx. Weight.	Average Power required.	Size of Driving Pulleys.	Speed of Driving Pulleys.	Prices.
No. 1	30in. by 5in.	35 cwt.	2½ horse	10in. by 4in.	750 revltns.	£90
No. 2	24in. by 5in.	28 ,,	2¼ ,,	8in. by 4in.	800 ,,	£60
No. 3	18in. by 5in.	22 ,,	2 ,,	8in. by 4in.	800 ,,	£52
No. 4	15in. by 4in.	18 ,,	1½ ,,	7in. by 3in.	800 ,,	£40

BRITANNIA WORKS, COLCHESTER, ENGLAND.

The A1 Combined Hand & Power Feed

Planing and Thicknessing Machine.



THE above Combination Planing Machine is simple in construction, occupies little space, and is specially adapted for the following work:—Taking out of twist any kind of stuff, making glue joints, surfacing straight or taper work, bevelling, chamfering, or squaring up. It will plane, with power feed, under the cutter, panels or boards any thickness, from one-eighth of an inch to the size the Machine is specified to take in.

The Machine is of very substantial construction. The table is fitted with special adjustable slides, having large wearing surfaces, and is raised or lowered by means of one screw, this screw being fixed under centre of table, onlp requires one pair of bevel wheels and one handwheel, whilst in other machines, to attain the same purpose, two screws and three pairs of bevel wheels are necessary.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

The Top Tables on which work is placed for passing over the cutter are made in halves, each half having a separate rising and falling motion, each regulated by handwheel and screw. These tables can be readily drawn apart when it is required to change or sharpen the irons.

A Fence is fitted on the top table, which is arranged to cant to any required bevel.

All the Feed Rollers are made of wrought iron, the front top roller being grooved so as to grip the work, and the necessary pressure is got by weights, made adjustable to suit light or heavy work. The two bottom friction rollers are fitted in the table. These rollers can be adjusted as required for the various kinds of wood to be worked.

A Flexible Pressure Bar placed on each side of the cutter block keeps the work level.

The Cutter Block is of an improved form, and the necks in which it revolves are of the best gun-metal, extra long and fitted with self-oiling lubricators.

The various adjustments enable the workman to make changes quickly.

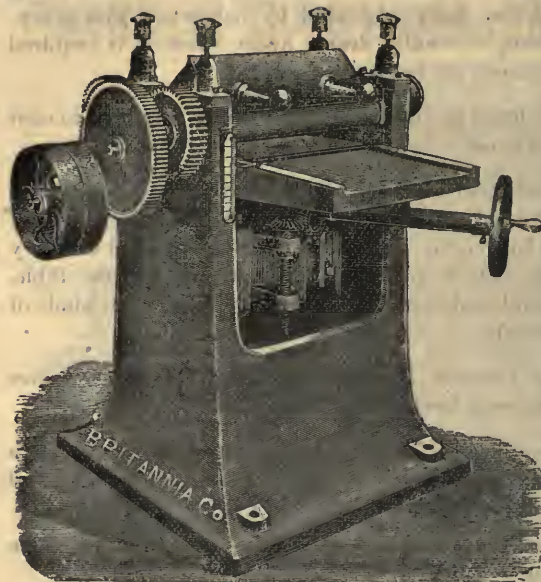
The Machine is provided with a gauge for indicating the thickness of stuff it will plane.

Size, No. 3, to take work 15in. wide and 5in. thick; Driving Pulleys on Countershaft, 6in. by 3in.; Speed of Countershaft, 800 revolutions; Approximate Weight, 17 cwt.; Power required, 1½-horse; Price £44 0 0

Size, No. 2, to take work 18in. wide and 6in. thick; Driving Pulleys on Countershaft, 7in. by 3in.; Speed of Countershaft, 800 revolutions; Approximate Weight, 17 cwt.; Power required, 1½-horse; Price £52 10 0

Size, No. 1, to take work 24in. wide and 6in. thick; Driving Pulleys on Countershaft, 8in. by 3in.; Speed of Countershaft, 800 revolutions; Approximate Weight, 28 cwt. 2qrs.; Power required, 2-horse; Price £62 10 0

Panel Planing and Thicknessing Machine.



THE above machine has been designed with a view to meet the several requirements of builders, cabinet makers, joiners, pattern makers, &c.

Lap board, cigar box and case makers will find it very useful as it is specially adapted for their class of work. By a little alteration of pressure bar and chip guard it can be made so as to work sash bars, window bars, and other kinds of moulded work. The framework is all one casting, made very strong to prevent any vibration or tremulous motion; the adze is made of steel, and planed out on two sides to form a back iron up to the knives, and revolves in long gun-metal bearings.

The feed rollers are made of wrought iron, and the pressure is readily adapted with strong springs, for either light or heavy work. The table is made strong and planed perfectly true on the top, and is fitted with two friction rollers working in gun-metal steps. These rollers are adjustable, and can be set to stand slightly above the top of the table.

The feed motion can be thrown out of gear instantly, and varied for three rates of feed. The table is made to rise and fall to suit various thicknesses of timber, by means of hand wheel and screw fixed on side of machine.

Size.	To work stuff	Take in stuff up to	Weight.	Power required.	Driving Pulleys.	Speed of ditto.	Price.
No. 4	15in. wide	4in. thick	13 cwt.	1 h.p.	6in. by 3in.	800	£26 0 0
No. 3	18in. wide	5in. thick	16 ,,	1¼ h.p.	7in. by 3in.	800	£32 10 0
No. 2	24in. wide	5½in. thick	20 ,,	1½ h.p	8in. by 3in.	800	£40 0 0
No. 1	30in. wide	6in. thick	30 ,,	2 h.p.	8in. by 4in.	750	£60 0 0

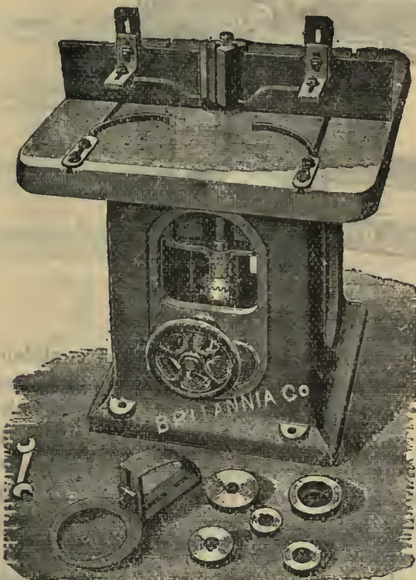
Any of the above-named Panel Planing Machines may be arranged so as to work moulds up to 5in. wide at an extra cost of 15s.

Any one of the above machines may be fitted with an apparatus for canting the table so as to plane work on the bevel, thus making an invaluable machine for the pattern-room of an engineer's or machinist's works, at an extra cost of £3.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

SINGLE SPINDLE

CIRCULAR MOULDING MACHINE.

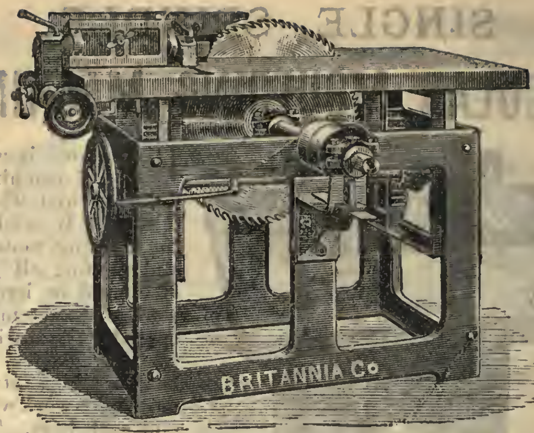


THE above is a very useful machine for Joiners and Cabinet Makers. It is adapted for shaping, moulding, and planing all kinds of curved or irregular work to wood templates or patterns. It will also tongue, groove, edge boards, stick straight moulds, or work window and sash bars. To facilitate the working of straight moulds, &c., it is fitted with a parallel adjustable fence and pressure springs. The framework is all in one casting, thereby giving strength and firmness, which are very requisite in machines of this class. The spindle is made of steel, and works in gun-metal bearings, and is arranged so as to revolve in either direction to suit the grain of wood to be worked. The work may be done by cutter blocks, with irons bolted on in the usual manner; or the iron may be fixed in a slot in the spindle, which is prepared to receive them, and where they are held in position by a set screw fixed in top end of spindle. The spindle is made to rise and fall by means of hand-wheel and screw; by this means the cutters may be readily adjusted to work at any desired height above the surface of the table. The machine has one cutter block, with cutter bolts and nuts, nut and washers for holding cutters in place, and set screw in top end of spindle.

Weight, with countershaft, 10 cwt. Power required, 2-horse. Driving pulleys on countershaft, 8in. by 2½in. Speed of same, 800.

Price, with one square cutter block, one pair of slotted washers, and with straight fence and side pressure springs	£22	0	0
If fitted also with straight and circular fences, as shown in the engraving at the foot of the machine...extra	1	5	0

BRITANNIA WORKS, COLCHESTER, ENGLAND.



By Her Majesty's Royal Letters Patent.

THIS Saw Bench is introduced by us with the greatest confidence, after a full practical trial. The patent gearing has been designed specially to give quick lifting with ease and certainty of action for very accurate work, and is sufficiently strong to lift much more than can possilby be needed, and is perfectly self-sustaining. The Spindle is of steel, and runs in long adjustable bearings of gun-metal, and has hole bored up at the end to receive augers, which are fastened by a set screw. The strap-fork is so constructed that it can be placed on either side of pulleys, being thus suitable for driving from any direction. The fence is arranged for sawing either square or at bevel, and has fine adjustment by screw and hand-wheel, and will turn over completely out of the way for cross-cutting. The Machines are very strong **(the 24in. size weighing 9cwt.),** and are well made and highly finished by skilful workmen. These Machines are at present made in three sizes, as per following List:

To admit Saw diameter	Table	Will cut fully through	Diam. of Pulley	Revtns. per Minute	Code Words.			
					Rising Top	Price	Stationary Top	Price
18in.	36″ × 20″	6½″ deep	5in.	2000	Design	£12 10	Designing	£10
24in.	48″ × 24″	9″ ,,	5½in.	1500	Introduce	£15	Introducing	£12 10
30in.	56″ × 28½″	11″ ,,	7in.	1200	Sustain	£19	Sustaining	£14 10

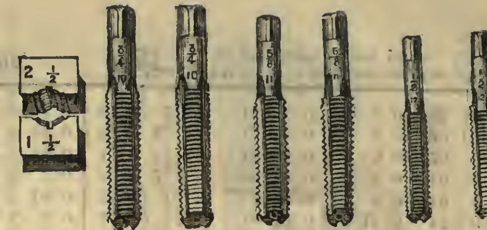
Above prices are proximate. Special quotations.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

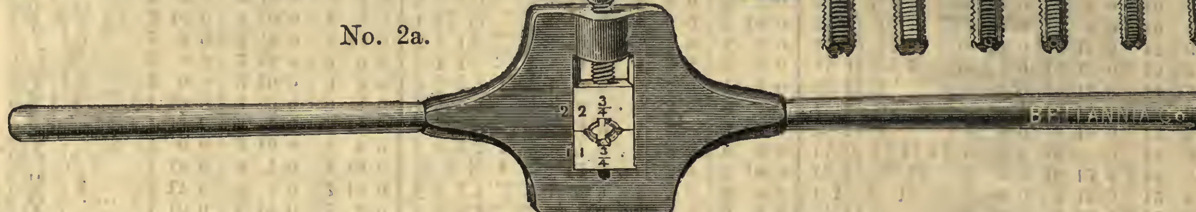
BEST STOCKS & DIES,

For Engineers' Use.

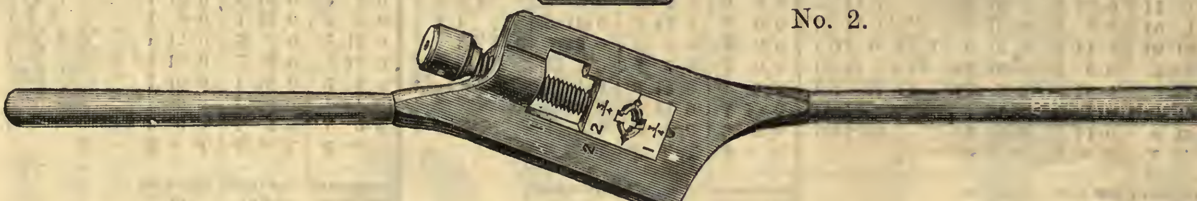
☞ *Whitworth's Standard Thread.*



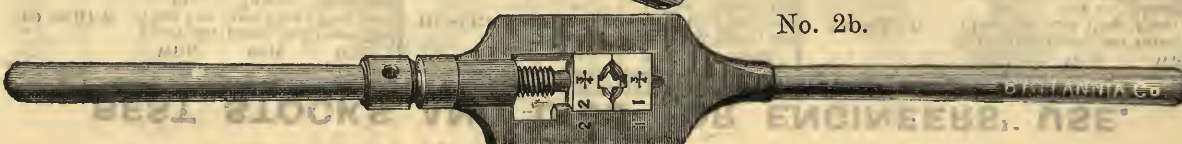
No. 2a.



No. 2.



No. 2b.



BEST STOCKS AND DIES FOR ENGINEERS' USE.

WHITWORTH'S STANDARD THREAD.

TO SCREW	With Taper and Plug Tap to each size (£ s. d.)	With Taper, 2nd and Plug Tap to each size (£ s. d.)	With Taper, 2nd Plug, and Master tap to each size (£ s. d.)
$\frac{1}{4}\ \frac{3}{8}$	1 0 0	1 4 0	1 9 0
$\frac{1}{4}\ \frac{5}{16}\ \frac{3}{8}$	1 5 0	1 10 0	1 17 0
$\frac{3}{16}\ \frac{1}{4}\ \frac{5}{16}\ \frac{3}{8}$	1 10 0	1 17 0	2 5 0
$\frac{1}{8}\ \frac{3}{16}\ \frac{1}{4}\ \frac{5}{16}\ \frac{3}{8}$	1 15 0	2 3 0	2 14 0
$\frac{1}{4}\ \frac{5}{16}\ \frac{3}{8}\ \frac{7}{16}$	1 17 0	2 5 0	2 15 0
$\frac{1}{4}\ \frac{3}{8}\ \frac{1}{2}$	1 9 0	1 15 0	2 3 0
$\frac{3}{8}\ \frac{7}{16}\ \frac{1}{2}$	1 10 0	1 17 0	2 5 0
$\frac{1}{4}\ \frac{5}{16}\ \frac{3}{8}\ \frac{1}{2}$	1 17 0	2 5 0	2 15 0
$\frac{5}{16}\ \frac{3}{8}\ \frac{7}{16}\ \frac{1}{2}$	1 18 0	2 7 0	2 18 0
$\frac{1}{4}\ \frac{5}{16}\ \frac{3}{8}\ \frac{7}{16}\ \frac{1}{2}$	2 6 0	2 16 0	3 9 0
$\frac{3}{8}\ \frac{1}{2}\ \frac{5}{8}$	1 12 6	2 1 0	2 11 0
$\frac{1}{4}\ \frac{3}{8}\ \frac{1}{2}\ \frac{5}{8}$	1 19 0	2 9 0	3 1 0
$\frac{3}{8}\ \frac{7}{16}\ \frac{1}{2}\ \frac{5}{8}$	2 0 0	2 10 0	3 3 0
$\frac{7}{16}\ \frac{1}{2}\ \frac{9}{16}\ \frac{5}{8}$	2 3 0	2 14 0	3 9 0
$\frac{1}{4}\ \frac{5}{16}\ \frac{3}{8}\ \frac{1}{2}\ \frac{5}{8}$	2 8 0	2 19 0	3 14 0
$\frac{1}{4}\ \frac{5}{16}\ \frac{3}{8}\ \frac{7}{16}\ \frac{1}{2}\ \frac{5}{8}$	2 16 0	3 10 0	4 7 0
$\frac{1}{2}\ \frac{5}{8}\ \frac{3}{4}$	2 0 0	2 10 0	3 3 0
$\frac{3}{8}\ \frac{1}{2}\ \frac{5}{8}\ \frac{3}{4}$	2 8 0	3 0 0	3 16 0
$\frac{9}{16}\ \frac{5}{8}\ \frac{11}{16}\ \frac{3}{4}$	2 13 0	3 8 0	4 6 0
$\frac{3}{8}\ \frac{7}{16}\ \frac{1}{2}\ \frac{5}{8}\ \frac{3}{4}$	2 16 0	3 11 0	4 9 0

TO SCREW	With Taper and Plug Tap to each size (£ s. d.)	With Taper, 2nd and Plug Tap to each size (£ s. d.)	With Taper, 2nd Plug, and Master tap to each size (£ s. d.)
$\frac{5}{8}\ \frac{3}{4}\ \frac{7}{8}$	2 7 0	3 0 0	3 15 0
$\frac{1}{2}\ \frac{5}{8}\ \frac{3}{4}\ \frac{7}{8}$	2 16 0	3 11 0	4 10 0
$\frac{11}{16}\ \frac{3}{4}\ \frac{13}{16}\ \frac{7}{8}$	3 1 0	3 19 0	5 1 0
$\frac{3}{8}\ \frac{1}{2}\ \frac{5}{8}\ \frac{3}{4}\ \frac{7}{8}$	3 7 0	4 4 0	5 5 0
$\frac{5}{8}\ \frac{3}{4}\ 1$	2 16 0	3 9 0	4 6 0
$\frac{3}{4}\ \frac{7}{8}\ 1$	2 16 0	3 11 0	4 9 0
$\frac{1}{2}\ \frac{5}{8}\ \frac{3}{4}\ 1$	3 7 0	4 3 0	5 2 0
$\frac{5}{8}\ \frac{3}{4}\ \frac{7}{8}\ 1$	3 7 0	4 5 0	5 8 0
$\frac{13}{16}\ \frac{7}{8}\ \frac{15}{16}\ 1$	3 12 0	4 13 0	5 18 0
$\frac{1}{2}\ \frac{5}{8}\ \frac{3}{4}\ \frac{7}{8}\ 1$	3 17 0	4 18 0	6 3 0
$\frac{7}{8}\ 1\ 1\frac{1}{8}$	3 4 0	4 2 0	5 3 0
$\frac{3}{4}\ \frac{7}{8}\ 1\ 1\frac{1}{8}$	3 16 0	4 18 0	6 5 0
$\frac{5}{8}\ \frac{3}{4}\ \frac{7}{8}\ 1\ 1\frac{1}{8}$	4 8 0	5 14 0	7 4 0
$\frac{3}{4}\ 1\ 1\frac{1}{4}$	3 4 0	4 2 0	5 3 0
$\frac{7}{8}\ 1\ 1\frac{1}{4}$	3 4 0	4 3 0	5 5 0
$1\ 1\frac{1}{8}\ 1\frac{1}{4}$	3 6 0	4 6 0	5 10 0
$\frac{3}{4}\ \frac{7}{8}\ 1\ 1\frac{1}{4}$	3 17 0	5 0 0	6 7 0
$\frac{7}{8}\ 1\ 1\frac{1}{8}\ 1\frac{1}{4}$	3 19 0	5 4 0	6 14 0
$\frac{3}{4}\ \frac{7}{8}\ 1\ 1\frac{1}{8}\ 1\frac{1}{4}$	4 12 6	6 2 0	7 18 0
$1\ 1\frac{1}{8}\ 1\frac{1}{4}\ 1\frac{3}{8}$	5 0 0	6 9 0	8 4 0

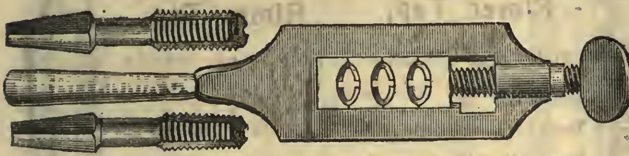
TO SCREW	With Taper and Plug Tap to each size (£ s. d.)	With Taper, 2nd and Plug Tap to each size (£ s. d.)	With Taper, 2nd Plug, and Master tap to each size (£ s. d.)
$1\ 1\frac{1}{4}\ 1\frac{1}{2}$	4 8 0	5 11 0	6 19 0
$1\frac{1}{4}\ 1\frac{3}{8}\ 1\frac{1}{2}$	4 14 0	6 1 0	7 13 0
$1\ 1\frac{1}{8}\ 1\frac{1}{4}\ 1\frac{1}{2}$	5 6 0	6 16 0	8 12 0
$1\frac{1}{8}\ 1\frac{1}{4}\ 1\frac{3}{8}\ 1\frac{1}{2}$	5 13 0	7 6 0	9 6 0
$1\ 1\frac{1}{8}\ 1\frac{1}{4}\ 1\frac{3}{8}\ 1\frac{1}{2}$	6 12 0	8 11 0	10 18 0
$1\frac{1}{4}\ 1\frac{1}{2}\ 1\frac{3}{4}$	6 10 0	8 4 0	10 1 0
$1\frac{1}{2}\ 1\frac{5}{8}\ 1\frac{3}{4}$	6 19 0	8 18 0	11 1 0
$1\ 1\frac{1}{4}\ 1\frac{1}{2}\ 1\frac{3}{4}$	7 16 0	9 16 0	12 0 0
$1\frac{3}{8}\ 1\frac{1}{2}\ 1\frac{5}{8}\ 1\frac{3}{4}$	8 3 0	10 12 0	13 5 0
$1\frac{1}{4}\ 1\frac{3}{8}\ 1\frac{1}{2}\ 1\frac{5}{8}\ 1\frac{3}{4}$	9 6 0	12 3 0	15 5 0
$1\frac{1}{4}\ 1\frac{1}{2}\ 2$	8 0 0	9 19 0	12 2 0
$1\frac{1}{2}\ 1\frac{3}{4}\ 2$	8 10 0	10 16 0	13 6 0
$1\frac{3}{4}\ 1\frac{7}{8}\ 2$	9 3 0	11 15 0	14 12 0
$1\frac{1}{4}\ 1\frac{1}{2}\ 1\frac{3}{4}\ 2$	10 4 0	12 18 0	15 17 0
$1\frac{5}{8}\ 1\frac{3}{4}\ 1\frac{7}{8}\ 2$	10 10 0	13 15 0	17 6 0
$1\frac{1}{2}\ 1\frac{5}{8}\ 1\frac{3}{4}\ 1\frac{7}{8}\ 2$	11 10 0	15 6 0	19 9 0
$1\frac{3}{4}\ 2\ 2\frac{1}{4}$	10 0 0	13 2 0	16 10 0
$1\frac{7}{8}\ 2\ 2\frac{1}{8}\ 2\frac{1}{4}$	13 15 0	18 5 0	23 0 0
$2\ 2\frac{1}{4}\ 2\frac{1}{2}$	12 0 0	16 3 0	20 10 0
$2\frac{1}{8}\ 2\frac{1}{4}\ 2\frac{3}{8}\ 2\frac{1}{2}$	16 5 0	22 4 0	28 10 0

Stocks and Dies Fitted in Oak or Deal Case to Order.

NOTICE.—We can now sell the above at two-thirds above prices.

Stocks and Dies for Brass and Copper Tube,

With Taper and Plug Tap to each size.

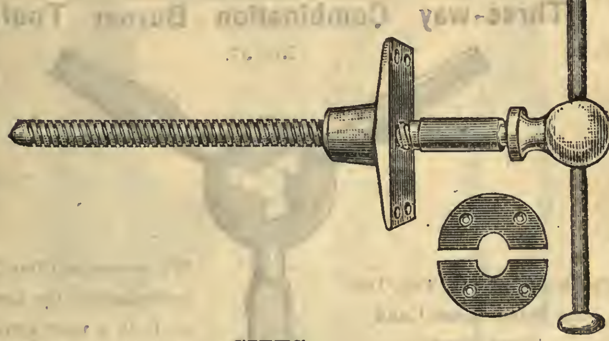


TO SCREW	PER SET	TO SCREW	PER SET	TO SCREW	PER SET
$\frac{1}{4}$ iron & $\frac{3}{8}$ & $\frac{1}{2}$ brass	15s.	$\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$ brass tube	16s.	$\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$ brass tube...	24s.
$\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$ brass.........	15s.	$\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$	18s.	$\frac{3}{4}$, $\frac{7}{8}$, 1	27s.
$\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$	15s.	$\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$	21s.	$\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, 1	33s.

For other Patterns and Sizes of Stocks and Dies see Special List.

Joiners' Bench Screw.

No. 44.



SIZES.

			s.	d.				s.	d.
1in.	Diameter by	14in. long	8	0	$1\frac{1}{4}$in.	Diameter by	20in. long	10	9
1	,,	16 ,,	8	6	$1\frac{3}{8}$	,,	19 ,,	12	3
$1\frac{1}{8}$	,,	16 ,,	9	0	$1\frac{3}{8}$	,,	21 ,,	13	0
$1\frac{1}{8}$	,,	18 ,,	9	6	$1\frac{1}{2}$	,,	20 ,,	14	3
$1\frac{1}{4}$	,,	18 ,,	10	0	$1\frac{1}{2}$	,,	22 ,,	15	9

Joiners' Cramps. Floor Cramps.

Lifting Jacks. Hydraulic Jacks.

No. 5.

IMPROVED

Rimer Tap,

FOR GAS MAINS.

Sizes	½″	⅝″	¾″	1″
Each	3/4	3/9	4/6	5/9
Sizes	1¼″	1½″	1¾″	2″
Each	8/-	10/6	15/6	17/9

No. 5A.

FLUTED

Rimer Tap,

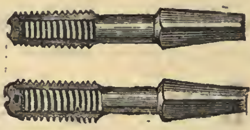
FOR GAS MAINS.

Sizes	¼″	⅜″	½″	⅝″	¾″
Each	1/3	1/6	2/-	2/3	2/6
Sizes	1″	1¼″	1½″	1¾″	2″
Each	3/6	4/6	6/-	8/9	11/-

No. 33.

Brass Gas Taps,

TAPER OR PLUG.

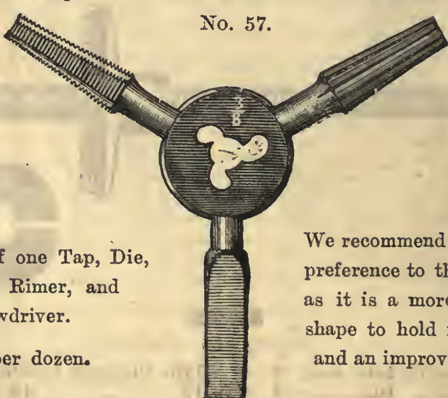


PRICE PER DOZ.

¼″	⅜″	½″	⅝″
8/6	10/-	11/6	12/6
¾″	⅞″	1″	
17/-	25/-	34/-	

Three-way Combination Burner Tool.

No. 57.



Consisting of one Tap, Die, fine-fluted Rimer, and Screwdriver.

55/6 per dozen.

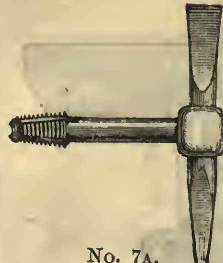
We recommend this Tool in preference to the four-way, as it is a more convenient shape to hold in the hand and an improved pattern.

Bellhanger's Cutting Plyers.

No. 54.

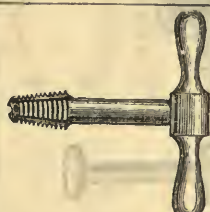
5in., 20/-; 6in., 25/-; 7in., 29/-; 8in., 34/- (per doz.).

Burner Taps.



No. 7A.
With Rimer & Turnscrew combined, 25/- per doz.

No. 56. 8/6 doz.

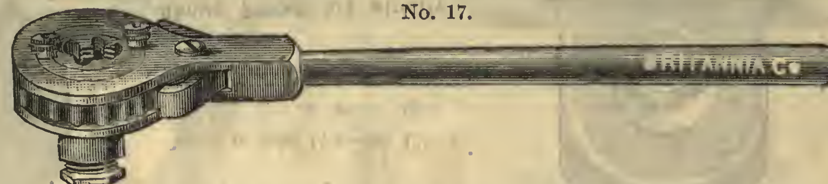


No. 7. With Handle, 17/- doz.

Patent Double-Action Ratchet Gas Stock,

WITH "SOLID" DIES SCREWING AT ONCE GOING OVER.

No. 17.

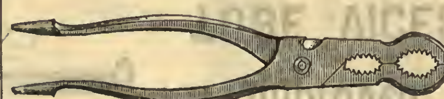


This stock is specially adapted for screwing pipes fixed in confined spaces, being Single-ended and having a right and left hand feed motion, it can be used where the ordinary Double-ended Stock would be of no use, a few inches only of space at the back of the pipe being all that is necessary for it to work in.

Sizes, to Screw Iron Gas Tubes	$\frac{1}{2}''$ $\frac{3}{4}''$ 1″	$\frac{3}{4}''$ 1″ $1\frac{1}{4}''$	1″ $1\frac{1}{4}''$ $1\frac{1}{2}''$	$1\frac{1}{4}''$ $1\frac{1}{2}''$ 2″
Price of Stock with Dies and Guides only, no Taps	60/-	80/-	100/-	120/-

Gas Plyers.

No. 18.



Sizes........................	8	9	10	inch.
	41/-	45/-	48/-	per doz.
If without Wire Cutter	29/-	32/-	36/-	,,

Gas Plyers, 2-Hole.

No. 9.

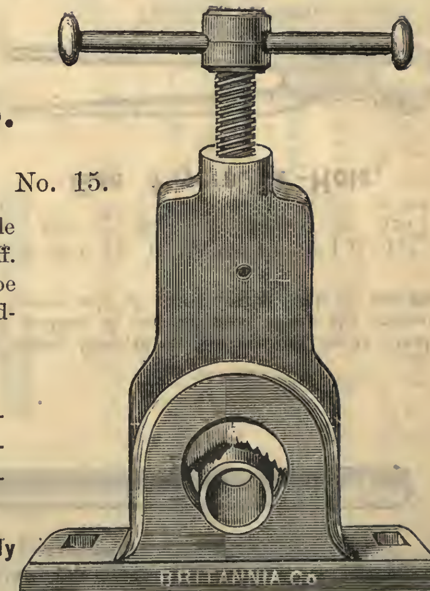
Price per Dozen.

7″	8″	9″	10″	11″	12″	14″	15″
14/-	17/-	20/-	23/-	26/6	30/-	37/-	43/-

Improved

TUBE VICES.

No. 14.



No. 15.

For holding Tube while being screwed or cut off. It is portable and can be fastened to a post or hand-cart by two bolts.

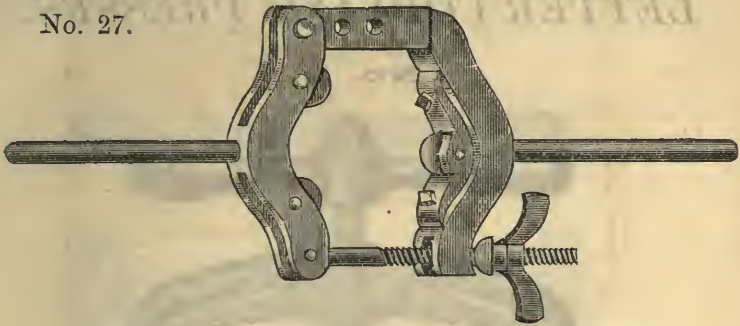
No. 1,	to take	$1\frac{1}{4}$ to $\frac{1}{4}$in.	12/-
,, 2,	,,	2 to $\frac{1}{4}$	15/-
,, 3,	,,	3 to $1\frac{1}{4}$	23/-

Above Prices are strictly Net Cash.

TUBE CUTTER.

FOR CUTTING CAST IRON MAIN PIPES.

No. 27.

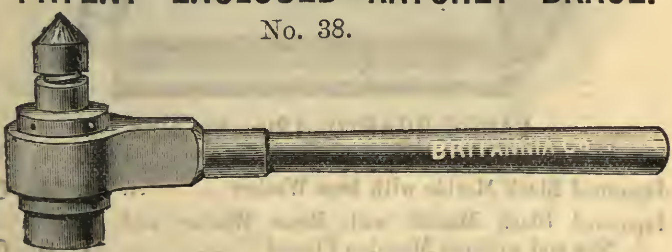


To cut 2 to 4 in. Tube,	28/- each.	Extra Cutters,	1/6 each.
,, 4 to 6 in. ,,	34/- ,,	,,	1/6 ,,
,, 5 to 8 in. ,,	40/- ,,	,,	1/6 ,,

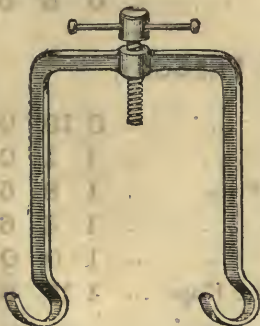
PATENT ENCLOSED RATCHET BRACE.

No. 38.

Drills at per dozen.



Sizes	10	12	14	16	18	20	22	24	inch.
	22/-	24/-	28/-	32/-	36/-	40/-	44/-	48/-	each.



Cramp for Drilling Main Pipes.

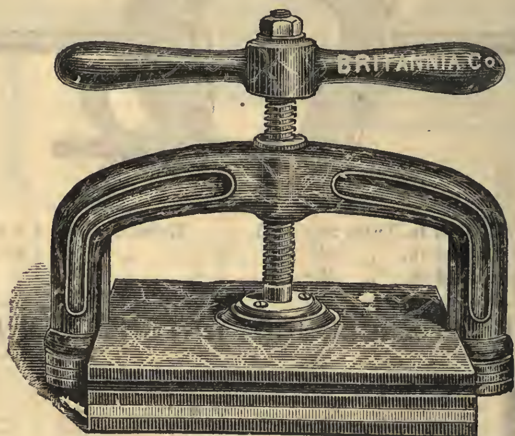
No. 45.

Sizes	2 to 4	4 to 6	5 to 8 inch.
	21/-	28/6	36/- each.
With Crank Brace	30/-	37/6	45/- each.

THE "BRITANNIA"

LETTER COPYING PRESSES.

No. 1.



LARGE QUARTO, 12in. by 10in.

	£	s.	d.
Japanned Black Marble with Iron Washer	1	1	0
Japanned Black Marble with Brass Washer and Nut and surfaces Machine Planed	1	5	0
Japanned Ornamentally and of very superior finish	1	10	0
Brass Ball Handles, extra	0	6	0

STANDS FOR THESE PRESSES.

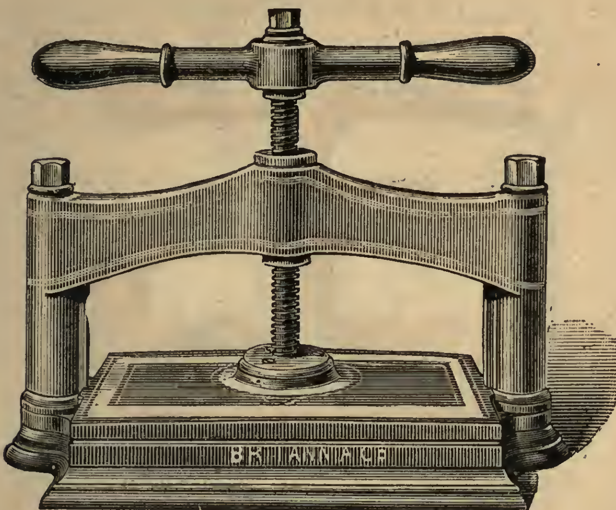
Birch, Polished, with 1 Drawer	0	19	0
Do. 2 Drawers	1	1	0
Do. 2 Drawers and 2 Flaps ...	1	8	6
Mahogany Polished, with 1 Drawer	1	4	6
Do. 2 Drawers	1	9	0
Do. 2 Drawers and 2 Flaps ...	1	17	6

BRITANNIA WORKS, COLCHESTER, ENGLAND.

THE "BRITANNIA"

LETTER COPYING PRESSES.

No. 2.



FOOLSCAP, 15in. by 10in.

	£	s.	d.
Extra Strong, Machine Planed, Gun-metal Washer and Nuts, Japanned Fillet	2	12	6
Extra Ornamented and Finished...	3	0	0
Gun-Metal Handles	0	8	0

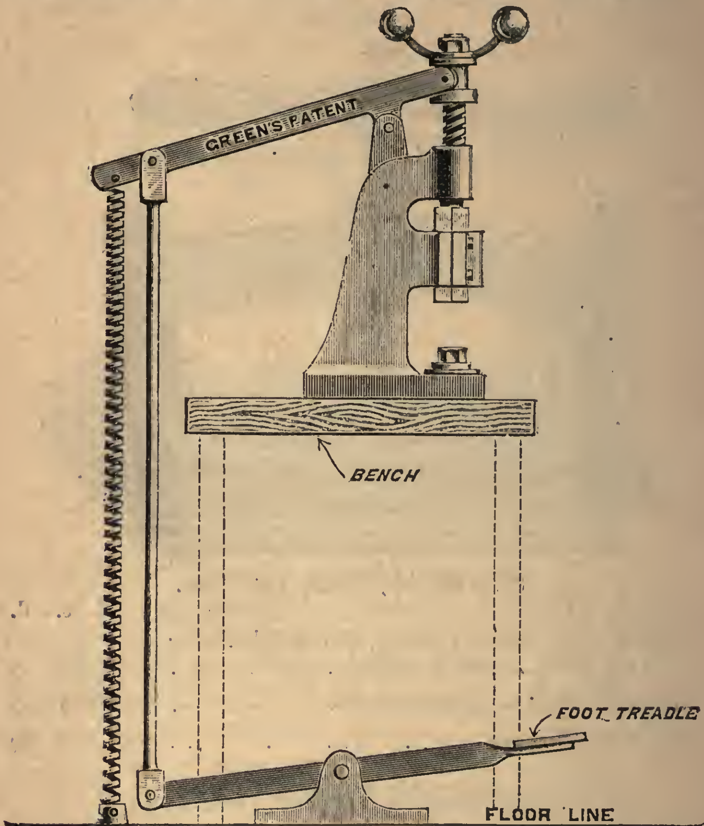
STANDS FOR THESE PRESSES.

Birch, Polished, with 1 Drawer	1	3	0
Do. 2 Drawers	1	5	0
2 Flaps, extra	0	10	0
Mahogany, Polished, 1 Drawer	1	9	0
Do. 2 Drawers	1	13	6
2 Flaps, extra	0	12	6

BRITANNIA WORKS, COLCHESTER, ENGLAND.

Green's Patent Foot Presses.

Great speed, Economy, & Accuracy. Both Hands of the Operator at liberty. Great Saving of Labour. Special Designs to suit all Trades.



THE attention of manufacturers is called to the very great advantages these Presses have over the ordinary kind. They are arranged to be worked by the FOOT instead of by HAND—thus enabling the operator to have BOTH hands at liberty to manipulate the work; thereby saving a great amount of time and making it EASY to perform RAPID operations with these Presses that are not possible with any others.

The improved arrangement of the Levers in combination with the screw and weighted "Fly," very greatly increases the power and efficiency of the Press, making it quite easy to work.

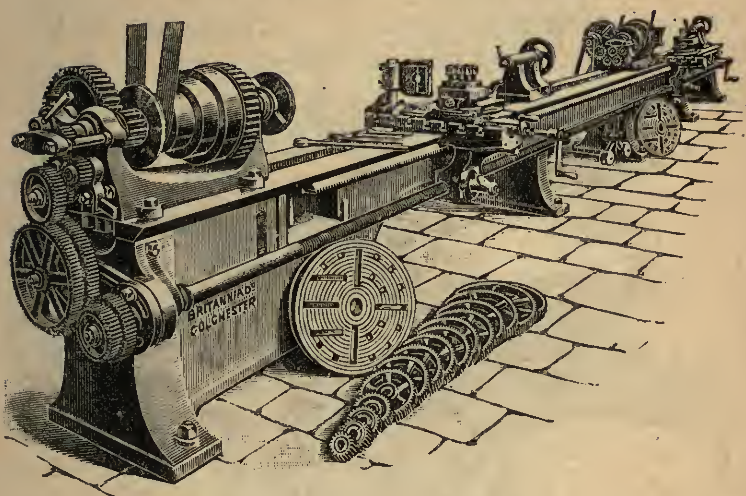
They are made and finished in first-class style: the screw and all the working parts being case-hardened.

PRICE from £6 10s.

FLY PRESSES OF EVERY DESCRIPTION.

LATHES,

with beds any length, with two or more heads on bed.



THE above Lathe is very useful in shops where occasionally long work is required to be done.

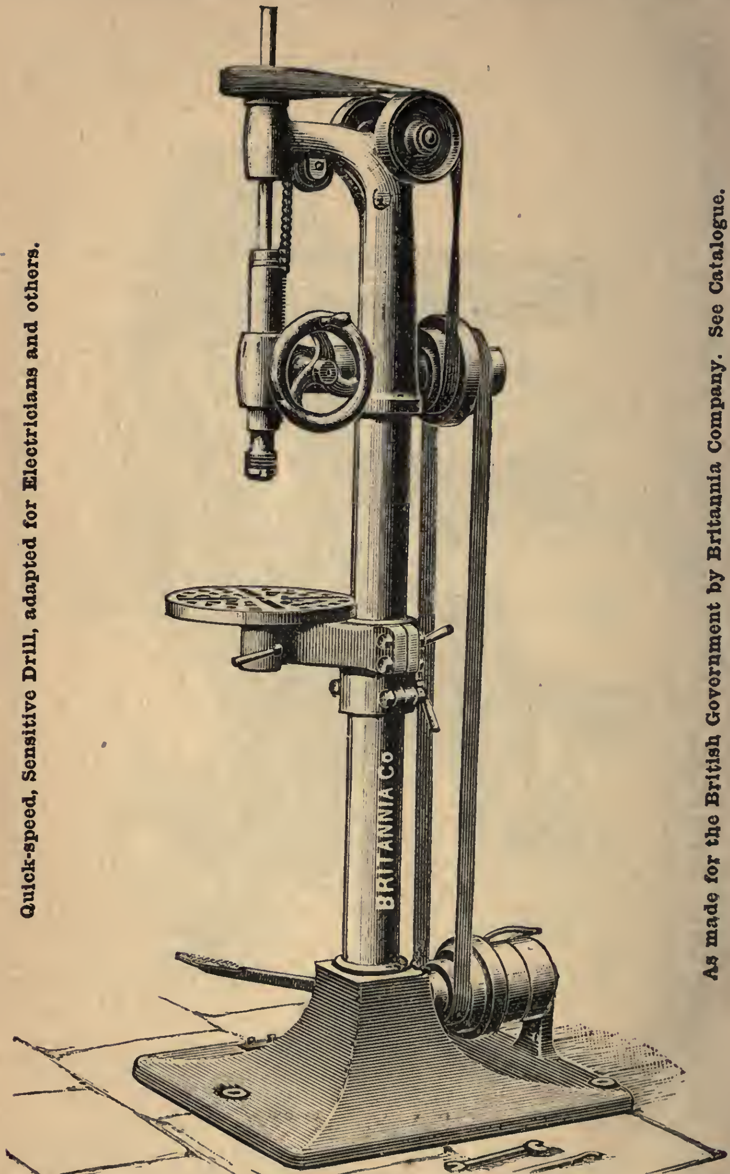
The intermediate heads can then be removed, and the whole length of Lathe is available. Both the saddles and rests can be used, one for roughing and one for finishing. Or two distinct jobs can be done at one time.

One man can work the two heads conveniently and economically.

Britannia Company's

QUICK-RUNNING, SENSITIVE DRILLING MACHINE.

Quick-speed, Sensitive Drill, adapted for Electricians and others.



As made for the British Government by Britannia Company. See Catalogue.

BRITANNIA WORKS, COLCHESTER, ENGLAND.

Notice to Engineers and others.

The Britannia Company, who have for many years designed and constructed Engineers' Tools for the British and other Govern=ments, Railway Companies and eminent Engineers, are now open to design

Special Tools

for any process.

Workshops and Factories fitted with Tools, shafting, Engines, &c.

Britannia Tool Factory,
Colchester, England.

Catalogues, 6d. post free.